Power BI from Rookie to Rock Star

Power BI Architecture

Reza Rad

RADACAD

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Times

- 9:00 am to 10:30 am – Course
- 10:30 am to 11:00 am – Morning Tea
- 11:00 am to 12:30 am – Course
- 12:30 am to 1:30 pm – Lunch
- 1:30 pm to 3:00 pm – Course
- 3:00 pm to 3:30 pm – Afternoon Tea
- 3:30 pm to 5:00 pm – Course

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What will you get?

- Handout (already printed and placed at your desk)
- All the files, PBIX, PDFs
- Access to the recording of this course (new edition WIP)
- Certificate of completion
- A digital version of the Power BI Architecture book edition 2

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RADACAD

Reza Rad

Consultant, Mentor, Trainer, Speaker
Blogger and YouTuber
Microsoft Regional Director
Microsoft Data Platform MVP
Author of 10+ Power BI video courses
Author of 13 Power BI books
Fasttrack Recognized Solution Architect
Co-Director of Power BI Summit and Difinity conferences

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Main Agenda

Development

Deployment

Sharing and Security

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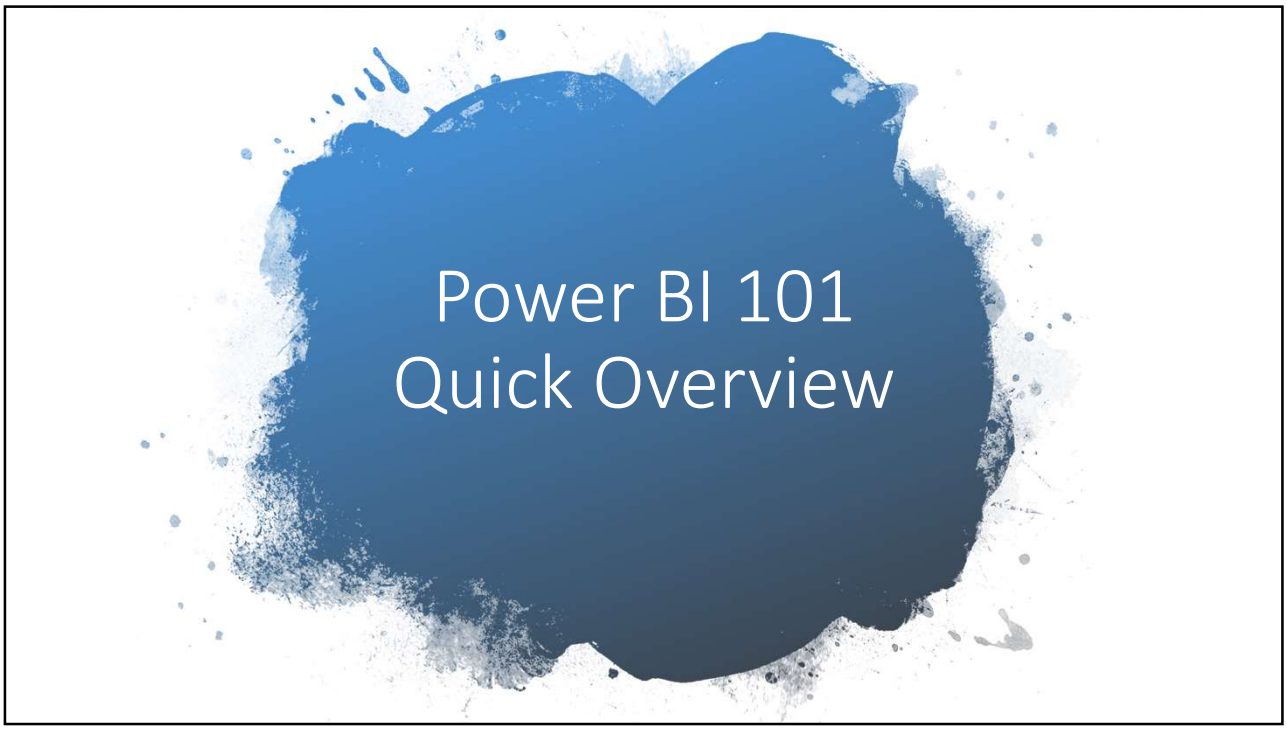

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Power BI Components

- What is Power BI?
- Power BI Desktop, Tool for Report Development
- Power Query for Data Transformation
- DAX and Modeling, the Analytical Engine
- Power BI Service for Hosting Reports
- Power BI Mobile App
- Power BI Report Server, an on-premises hosting for Power BI
- Power BI Report Builder; for building paginated reports
- On-Premises Gateway
- Dataflow
- Datamart
- Dataset
- Report
- Paginated Report
- Dashboard
- Metrics and Scorecards
- Deployment pipelines
- Workspaces
- Power BI App
- Power BI Premium
- Power BI Embedded
- Developer API

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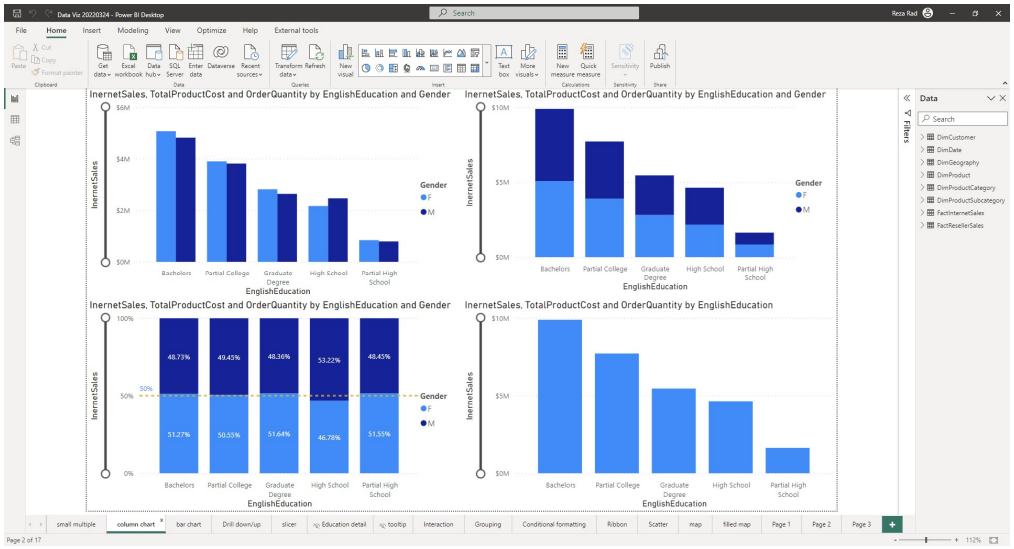
Power BI Desktop: Author/Dev Tool



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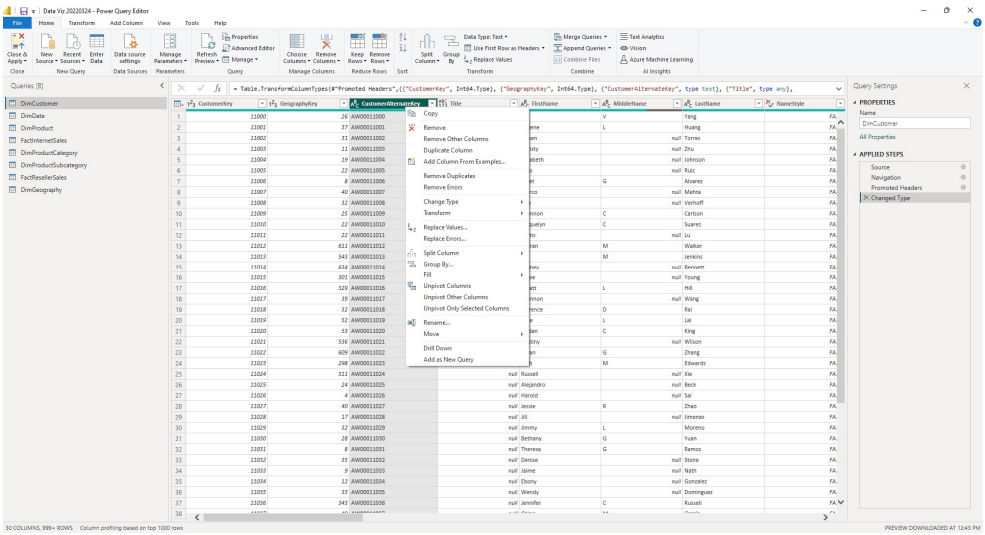
Power Query: Data Transformation Engine



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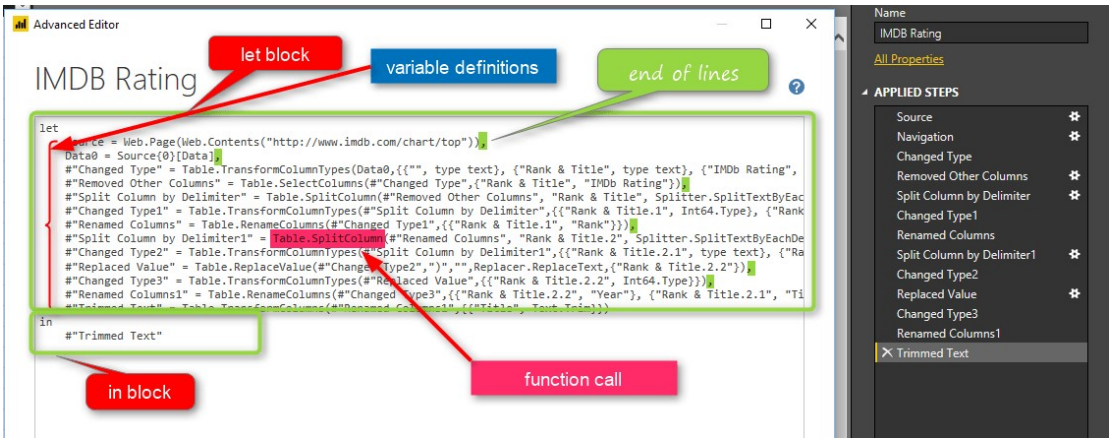
M: Language for Power Query



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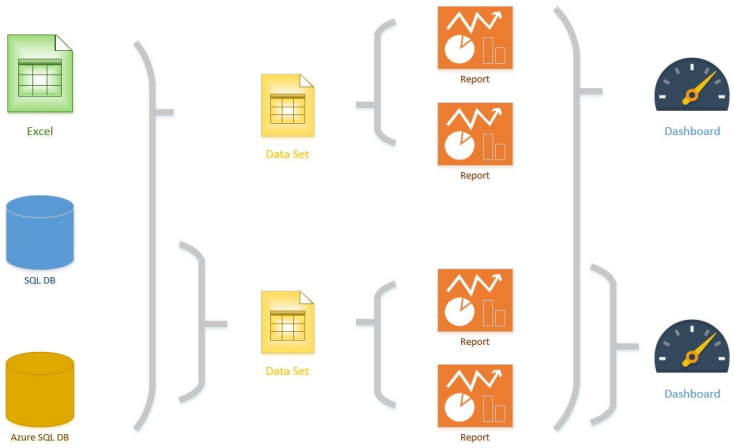
Report, Dataset and Dashboard



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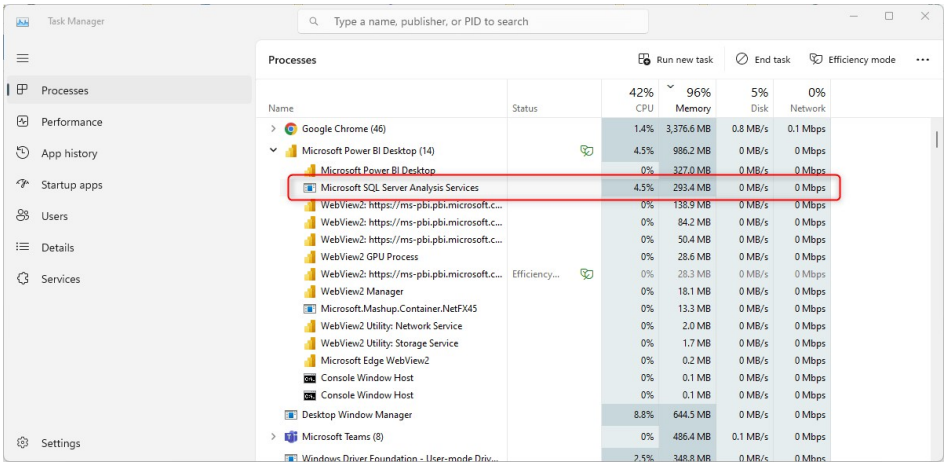
Analytical Engine (Tabular Engine, Vertipaq)



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DAX; Data Analysis eXpression Language

```
InernetSales YTD =
TOTALYTD(
        SUM('FactInternetSales'[InernetSales]),
        'DimDate'[FullDateAlternateKey].[Date]
    )
```

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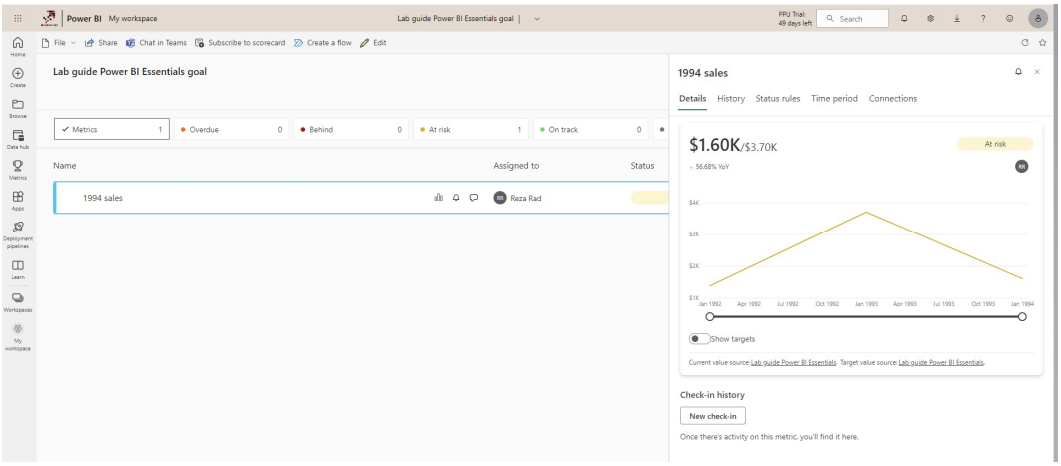
Metrics and Scorecards



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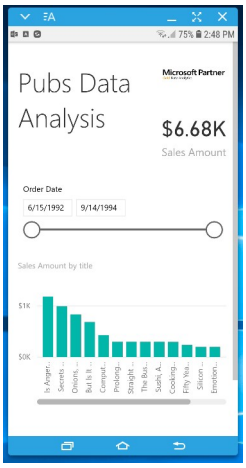
Power BI Mobile App



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Development

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Agenda: Development

- Import Data or Schedule Refresh
- DirectQuery
- Live Connection
- Composite Mode
- DirectQuery to Power BI Dataset
- Choosing the Right Connection Type
- Dataflows
- Shared Datasets
- Datamart
- Multi-Developer Architecture
- Dataflow vs Dataset vs Datamart
- Paginated Reports
- Analyze in Excel
- Realtime streaming with Power BI
- Power BI Aggregations
- Incremental Refresh
- Power BI Development Best Practices

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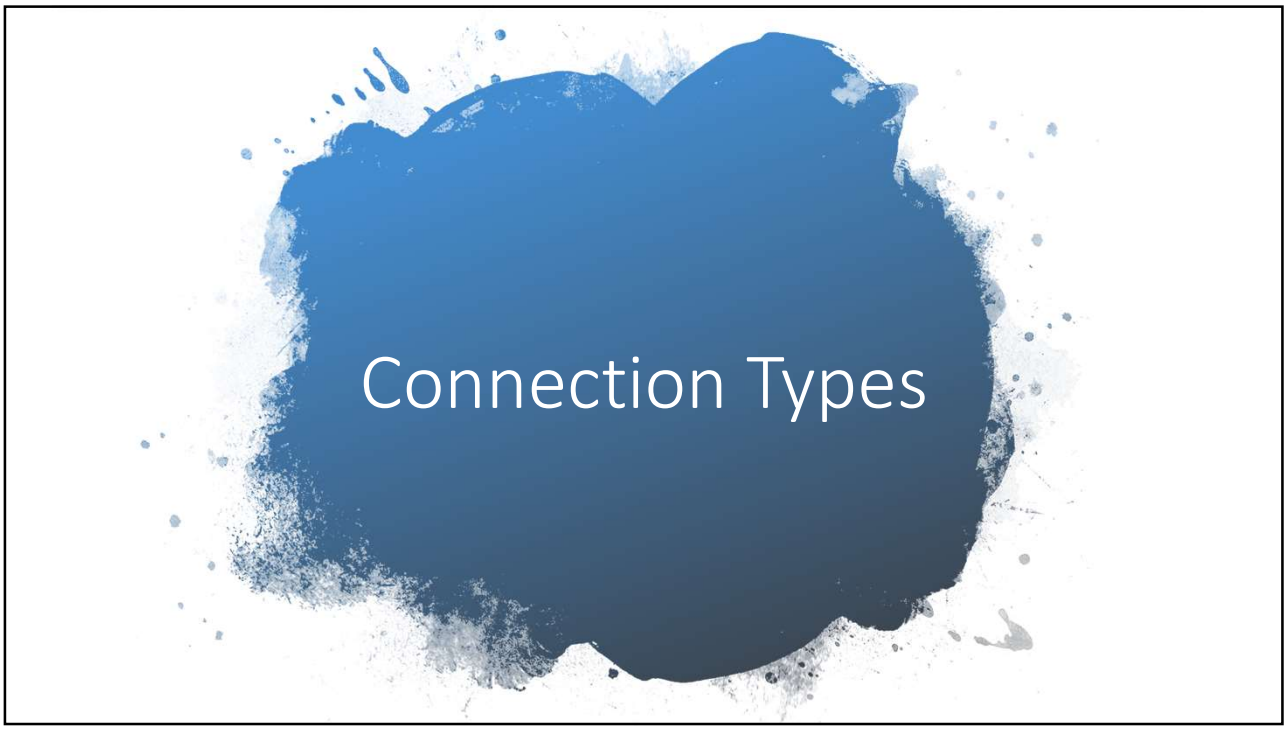

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Five Types of Connection

- Import Data / Scheduled Refresh
- DirectQuery
- Live Connection
- Composite Mode
- Direct Lake

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Import Data

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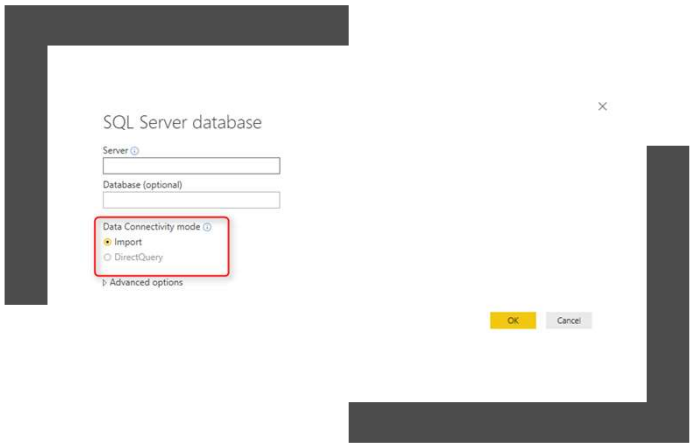
Import Data / Scheduled Refresh



- Up to date data only via refresh
- Full Power BI functionality: DAX, M, and Visualization
- Fastest Power BI Solution
- Limited Size: 1GB per file (Pro), 2GB per file (RS), 400GB per file (Premium, as much as your capacity allows)

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xVelocity Data Compression

4 bytes	4 bytes	4 bytes	8 bytes	3 bytes	16 bytes	16 bytes	
Order ID	Quarter	Quantity	Sales Amount	Oder Date	uniqueidentifier	text	other columns
1	1	5	43254	7/01/2017			
2	1	2	123423	8/01/2017			
3	1	67	234	9/01/2017			
4	1	1	523	10/01/2017			
5	1	7	132	11/01/2017			
6	1	34	675	12/01/2017			
7	1	3	79678	13/01/2017			
8	2	8	90780	10/05/2017			
9	2	45	89	11/05/2017			
10	2	9	868	12/05/2017			

Total each row: 100 bytes

Number of rows: 100 Million

Total space needed: 100M * 100bytes= 10GB

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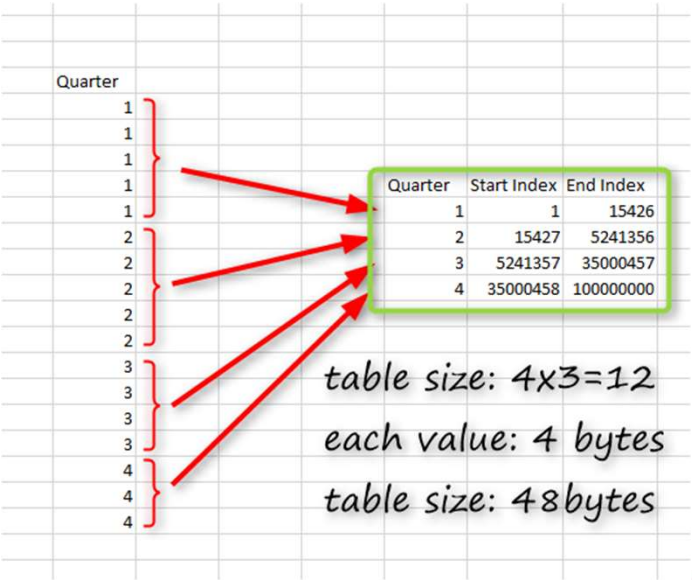
Compressed Data



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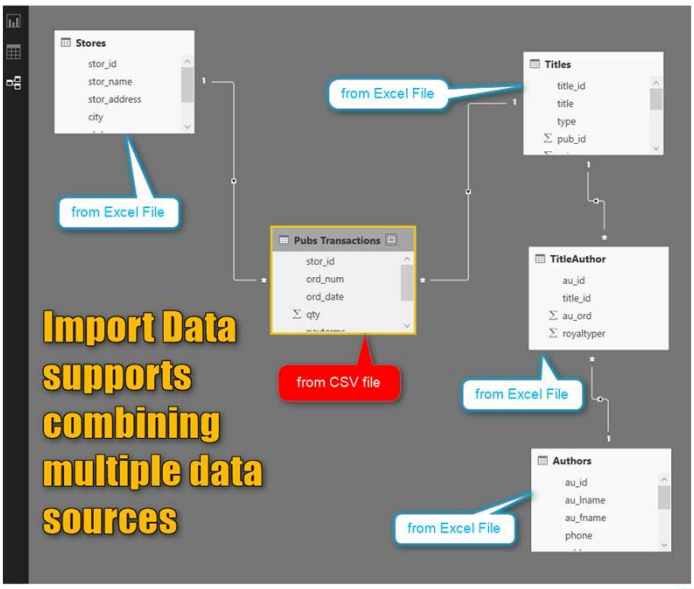
Import Data

- Super Fast
- Flexible



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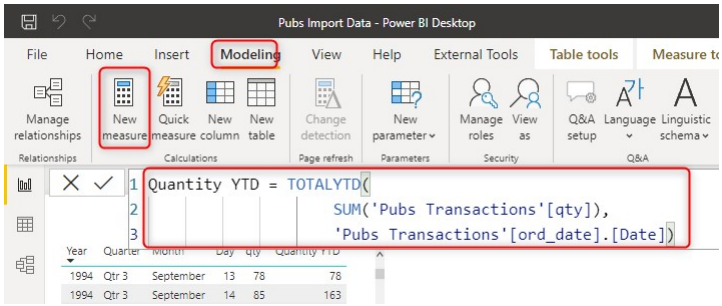
Import Data: Pros and Cons

- Super Fast (In-Memory)
- Full Flexibility: DAX and Power Query
- Schedule Refresh
- Large Dataset



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DirectQuery

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DirectQuery Data Sources

- Amazon Redshift
- Azure HDInsight Spark (Beta)
- Azure SQL Database
- Azure SQL Data Warehouse
- Google BigQuery (Beta)
- IBM DB2 database
- IBM Netezza (Beta)
- Impala (version 2.x)
- Oracle Database (version 12 and above)
- SAP Business Warehouse Application Server
- SAP Business Warehouse Message Server (Beta)
- SAP HANA
- Snowflake
- Spark (Beta) (version 0.9 and above)
- SQL Server
- Teradata Database
- Vertica (Beta)

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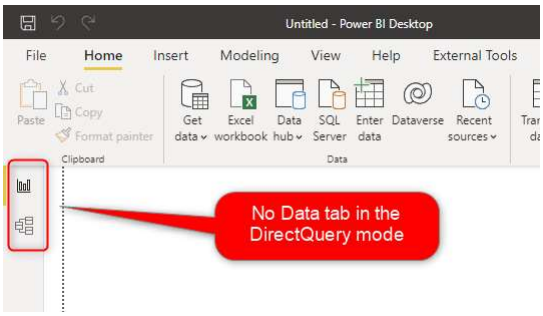
Data Stays in the Data Source



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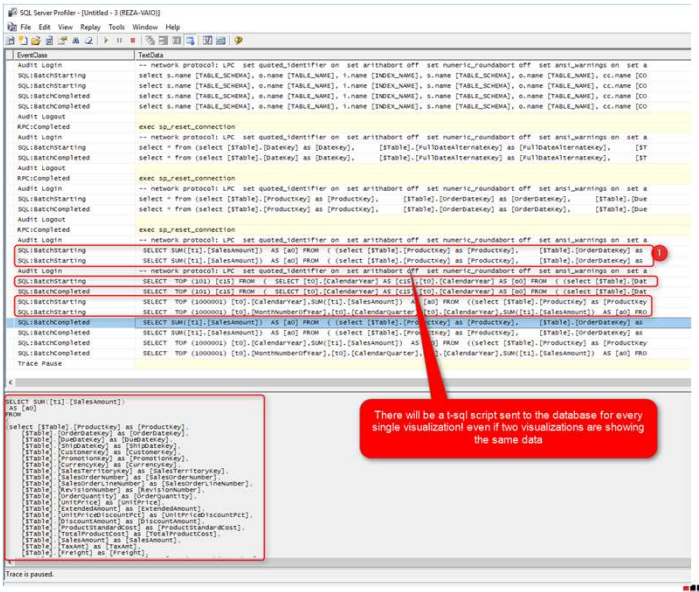
Query to the Data Source



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Query per visual

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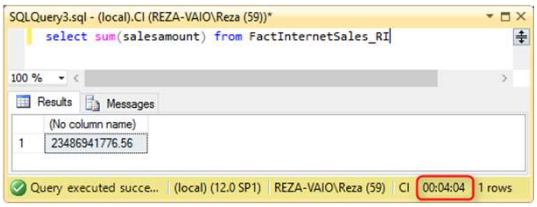
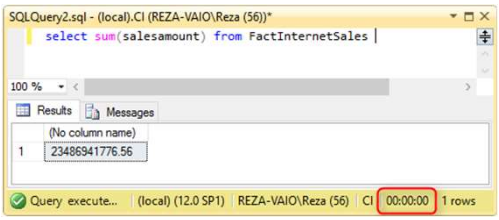
Performance Tuning for Data Sources

- 48 million records
- Regular Index

- 48 million records
- Column-store Clustered Index





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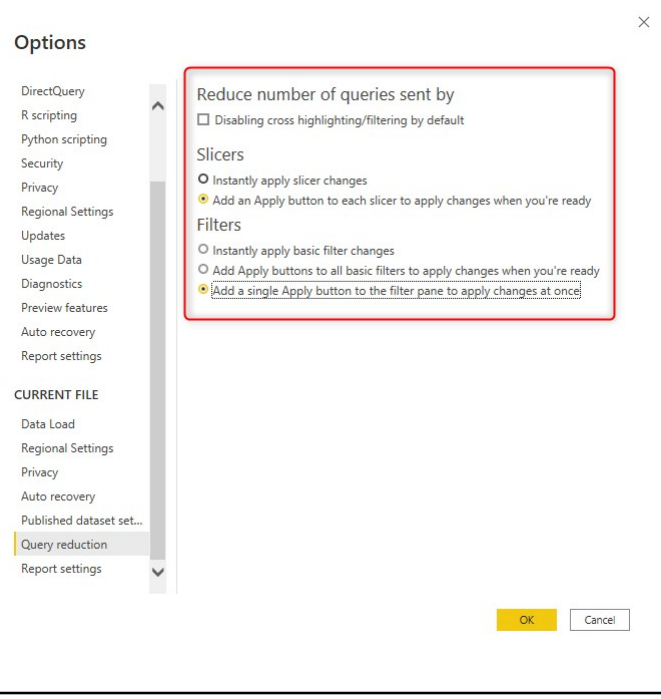
Query Reduction



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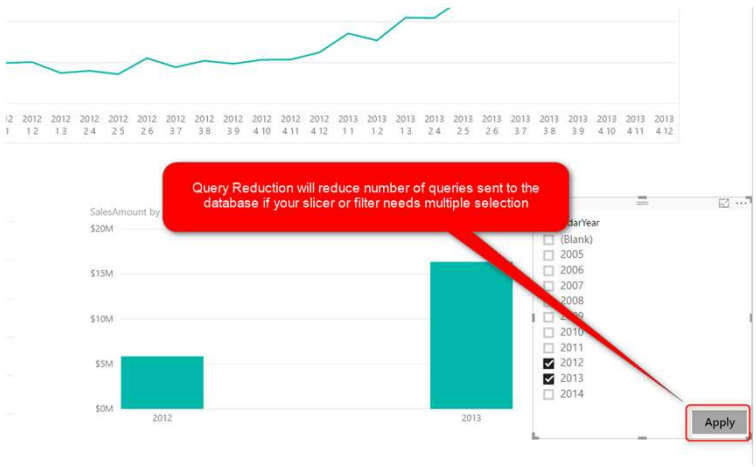
Query Reduction: Better Performance



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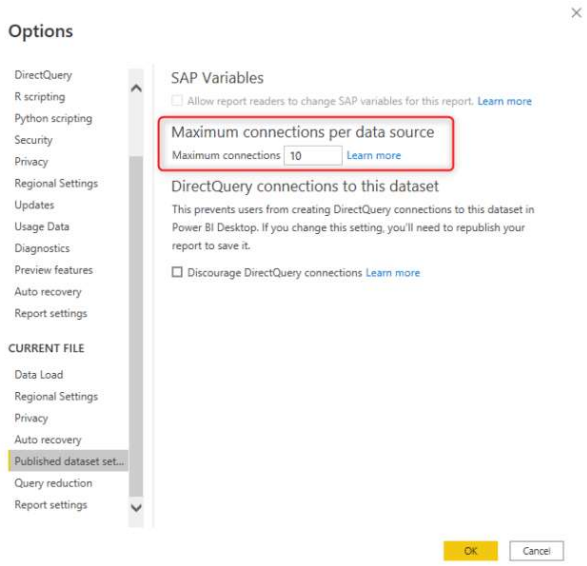
Maximum connections per data source



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Connections: Also consider users

ENVIRONMENT	UPPER LIMIT (ACTIVE CONNECTIONS PER DATA SOURCE)
Power BI Pro	10
Power BI Premium	30
Power BI Report Server	10

Maximum connections per data source setting for DirectQuery

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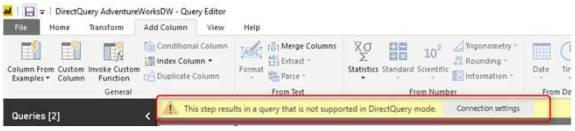
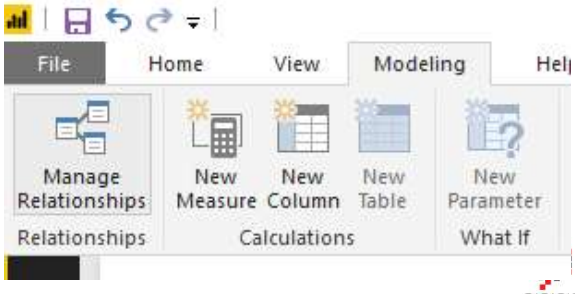
Limited Power Query and DAX





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DirectQuery: Pros and Cons

Advantages

- Large Scale Dataset; Size limitation only for the data source itself
- No need for data refresh

Disadvantages *(many of these can be fixed using Composite Mode)*

- Power Query transformations are limited
- Modelling is limited
- DAX is limited
- Lower speed of the report

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Live Connection

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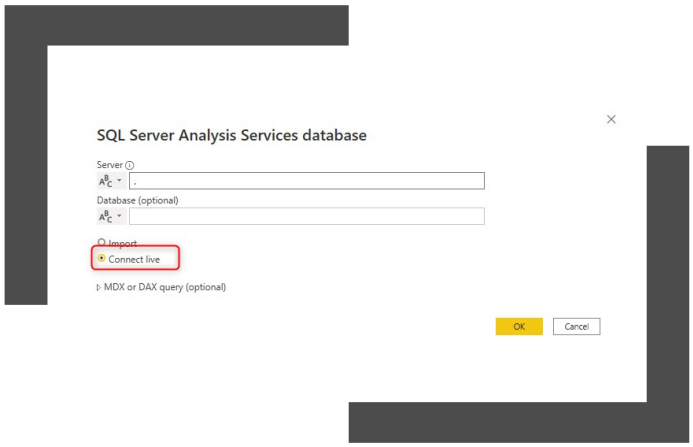
Live Connection



- SQL Server Analysis Services Tabular
- SQL Server Analysis Services Multi-Dimensional
- Azure Analysis Services
- Power BI Dataset

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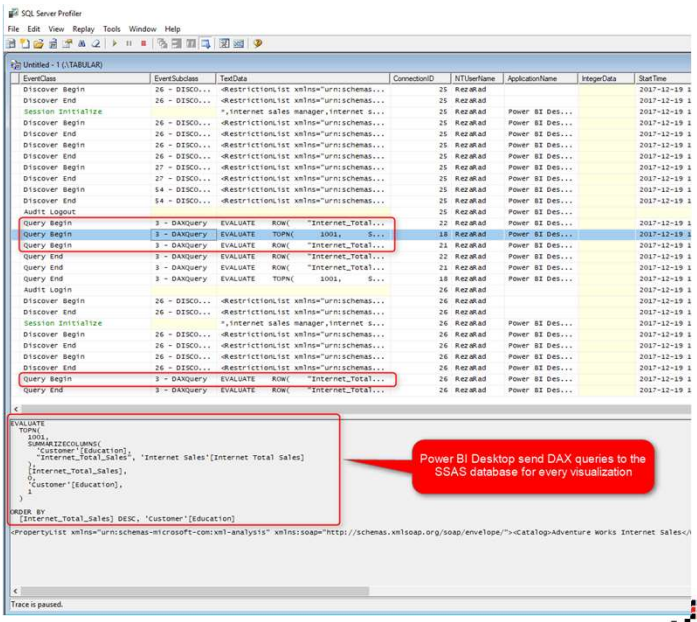
How Live Connection Works?



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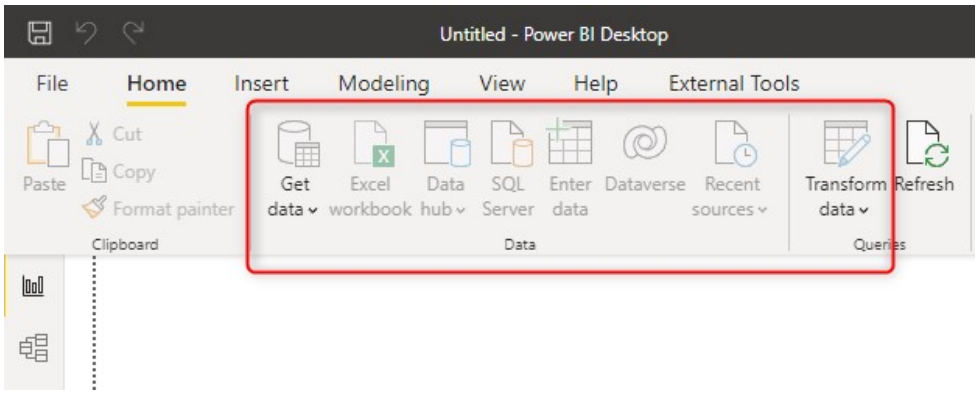
No Power Query



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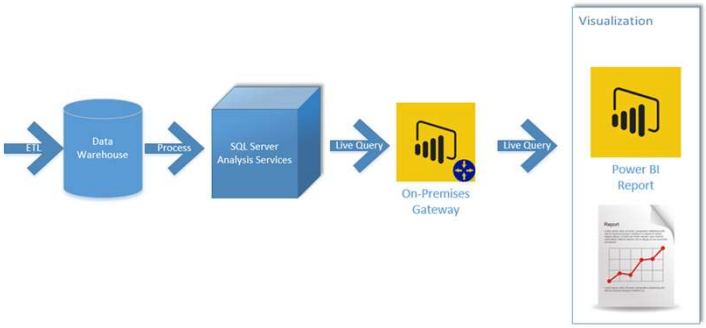
Enterprise usage of Live Connection



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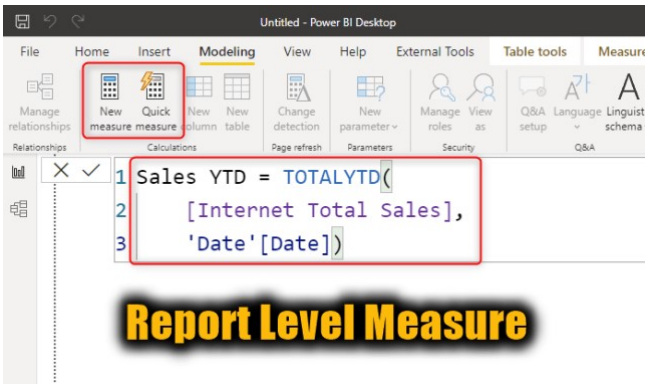
Report Level Measure



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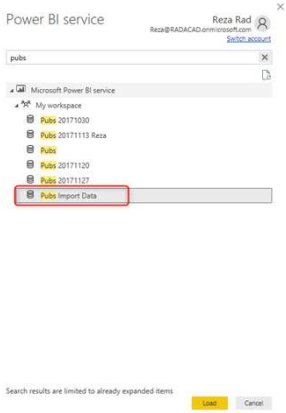
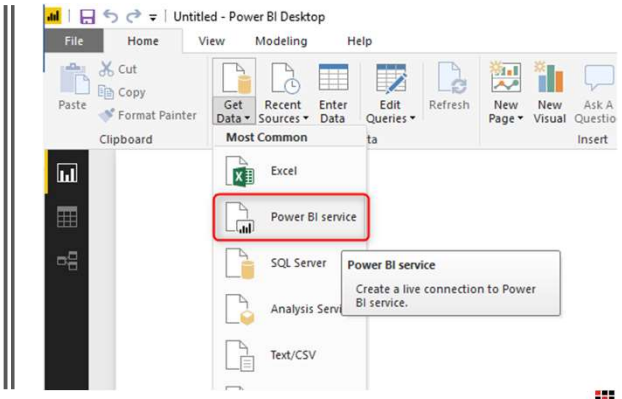
Live Connection to Power BI Dataset





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Live Connection is different from DirectQuery

- DirectQuery is a connection mainly to a non-Microsoft database or analytical engines, or to relational databases. (such as SQL Server, Teradata, Oracle, SAP Business Warehouse, etc)
- Live Connections is a connection to four sources: SSAS tabular, SSAS multi-dimensional, Azure Analysis Services, and Power BI dataset.
- DirectQuery for some of the data sources (such as SQL Server database) still has a limited Power Query functionality available.
- Live Connection has no Power Query features in it.
- You can create some simple calculated columns in DirectQuery; these will be converted to T-SQL scripts behind the scene.
- You cannot create calculated columns in Live Connection.
- You can use Report-Level measures with the ability to leverage all DAX functions in a Live connection.
- In the DirectQuery mode, you can have limited measure abilities. For more complex measures, you must check the performance (and some of the functions such as parent-child functions are not available), some complex measures might slow down the performance significantly.
- DirectQuery mode usually is slower than Live connection.
- A live connection is usually less flexible than DirectQuery.

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Live Connection: Pros and Cons

Pros

- Faster than DirectQuery
- Enterprise Approach
- DAX

Cons

- More limitations than DirectQuery
- Longer Development Life Cycle

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Composite Mode

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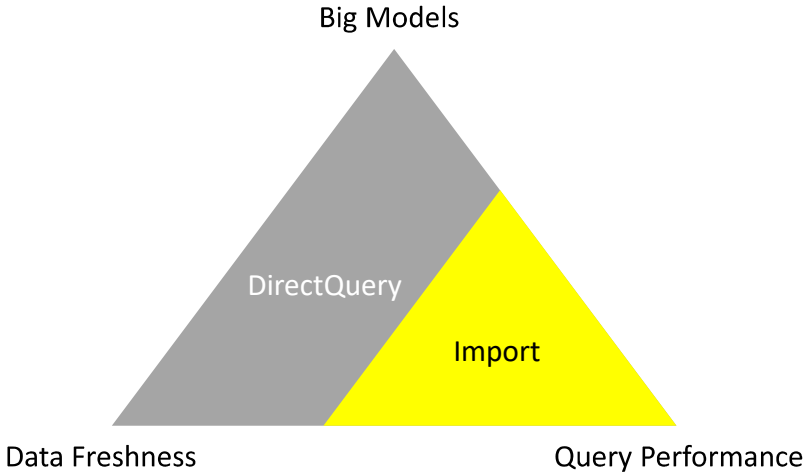
Import vs. DirectQuery



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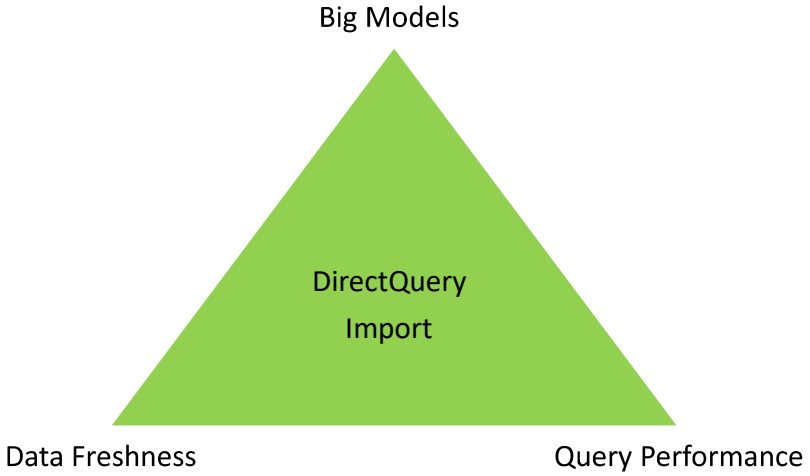
Import vs. DirectQuery



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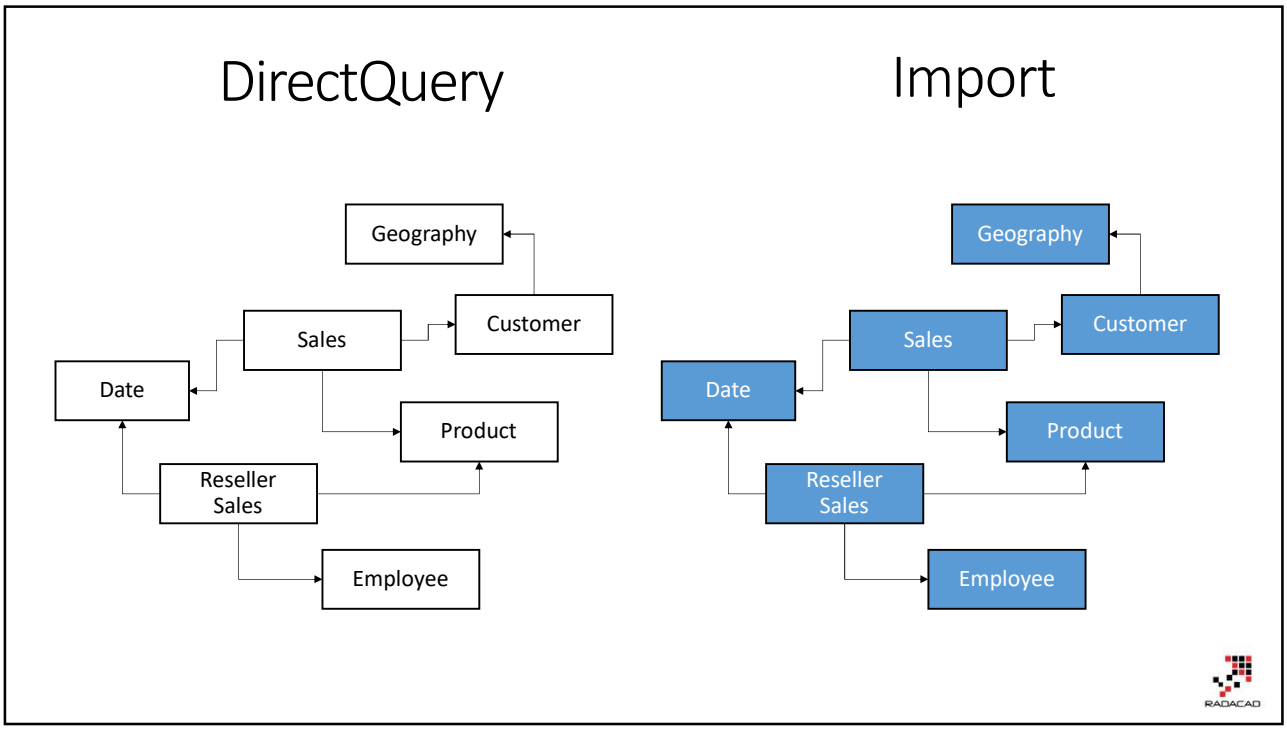
DirectQuery
Geography
Customer
Sales
Date
Product
Reseller Sales
Employee
Import
Geography
Customer
Sales
Date
Product
Reseller Sales
Employee

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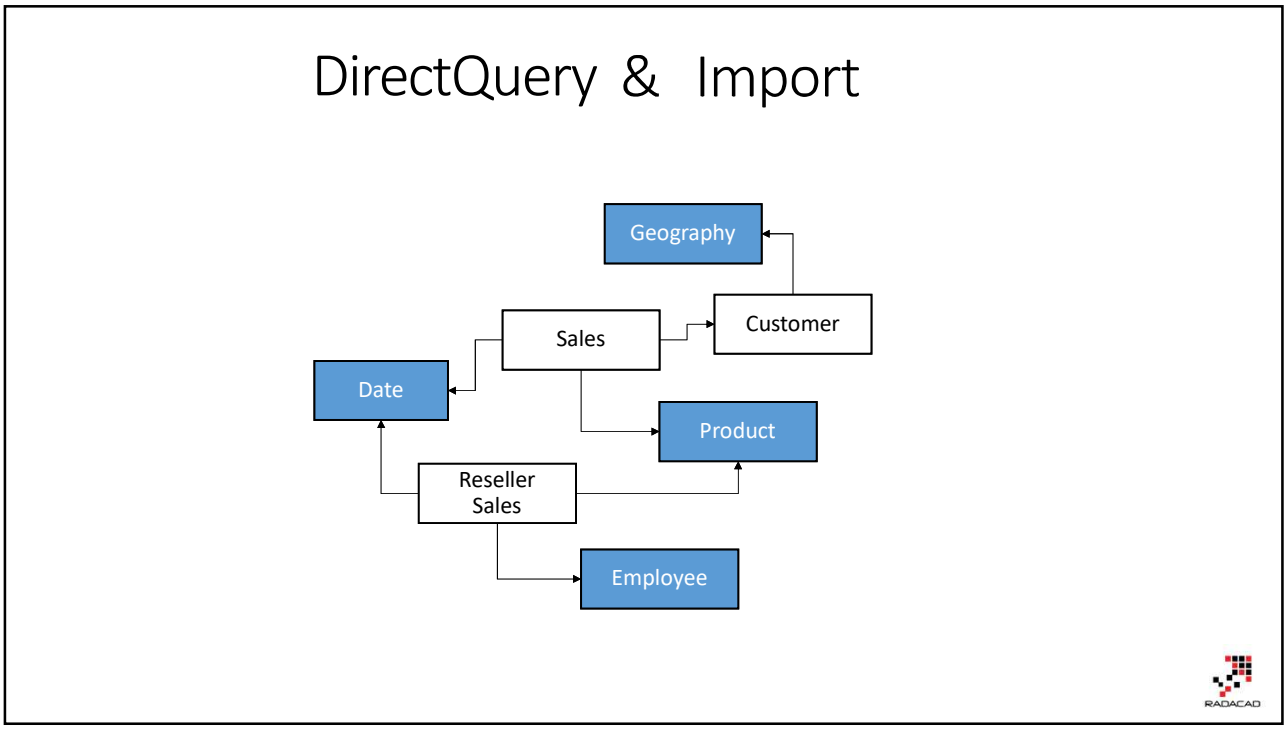
DirectQuery & Import
Geography
Customer
Sales
Date
Product
Reseller Sales
Employee

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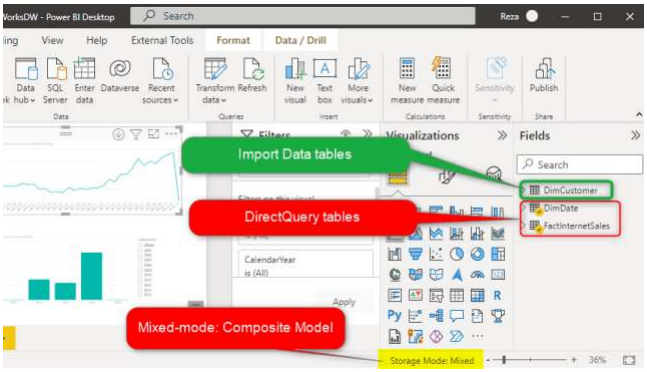
Composite Mode in Power BI Desktop



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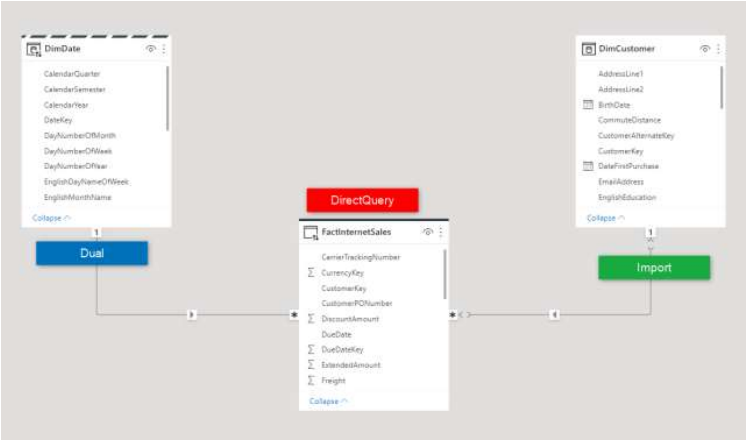
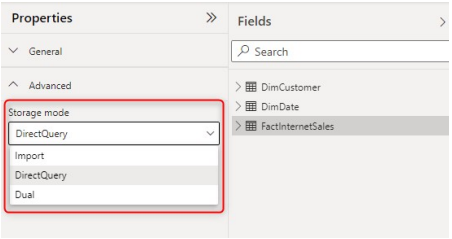
Storage Mode





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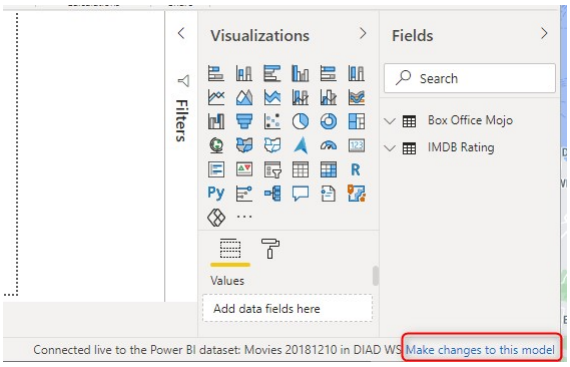
DirectQuery to Power BI Dataset



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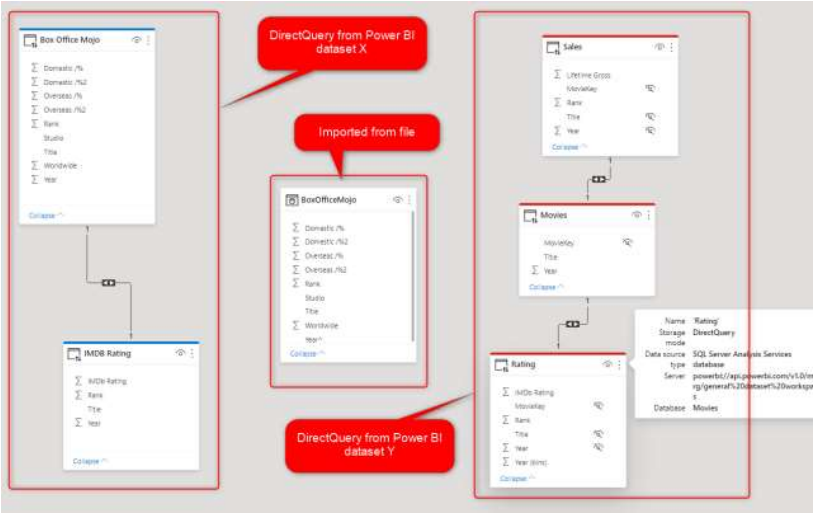
Multiple DirectQuery connections



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Direct Lake

Microsoft Fabric

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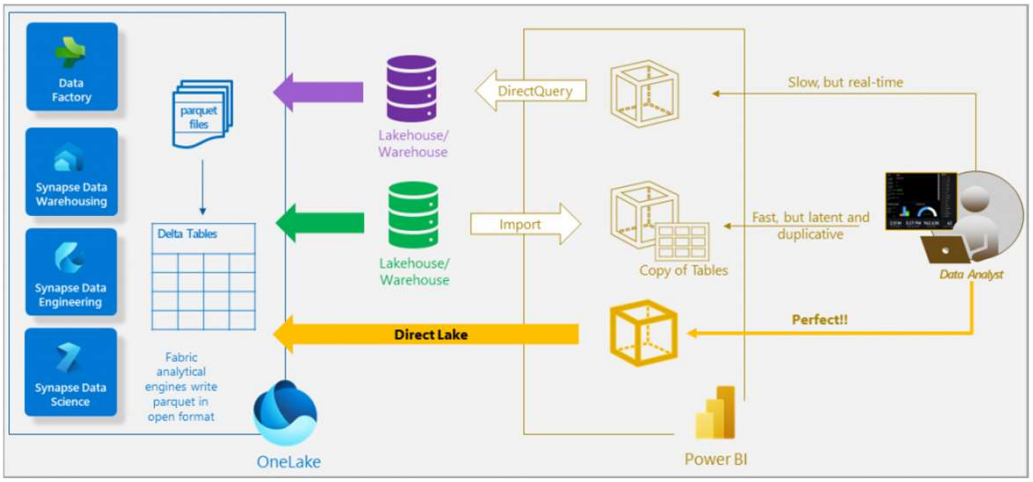
Direct Lake



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How Direct Lake works

- Using a Lakehouse
- Building the dataset using the web experience

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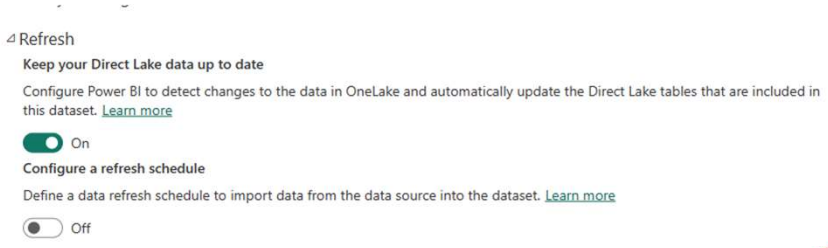
Refresh

- The default dataset gets refreshed as soon as the Lakehouse's data gets updated
- Custom datasets can be set as "Keep your Direct Lake data up to date" or not



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Choosing the Right Method of Connection

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Which method performs the fastest?

1. Import Data (Composite Mode, the import part of it)
2. Live Connection
3. DirectQuery

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Which Method is more Flexible?

1. Import Data
2. Composite Mode
3. DirectQuery
4. Live Connection

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Which method is more scalable?

- Direct Query (Composite mode, the DirectQuery part of it)
- Live Connection
- Import Data

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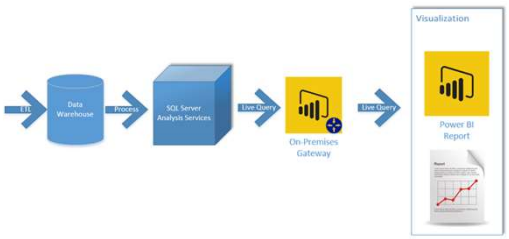
Architecture Choice

- Import Data for Agility and Performance
- Live Connection for Enterprise Solution
- Live Connection for Team Development
- DirectQuery for Non-Microsoft Sources

65

Enterprise Hybrid Setup

- SSIS or ADF or … for ETL -> Loading data into data warehouse (Azure SQL DB, on-prem database…)
- SSAS on-prem or Azure AS for the data model -> preferably Tabular
- Power BI Live connection to the AS tabular model



66

Big Data Architecture: Composite Model

- Composite Model
- Combined version of DirectQuery and Import Data

- Works fast with peta bytes of data
- Works with aggregated data and detailed data through multiple layers

67

Dataflow

68

Single Business Analyst/Developer

- One Developer: Business Analyst
- One Reporting problem to solve: One Power BI Solution (File)
- Multiple Users (end users)

69

Architecture: One Single File, Import Mode

- Everything in One Power BI File
- FAST to develop
- Fast to respond (because it is import mode)
- Agile: easy to make changes in PQ, data model, DAX and visualization
- Easy to maintain

70

Analyst's team: Multiple Developers

- A team of developers: Or Business Analysts
- One or more reporting problems to solve
- Multiple users

71

Single File Challenges

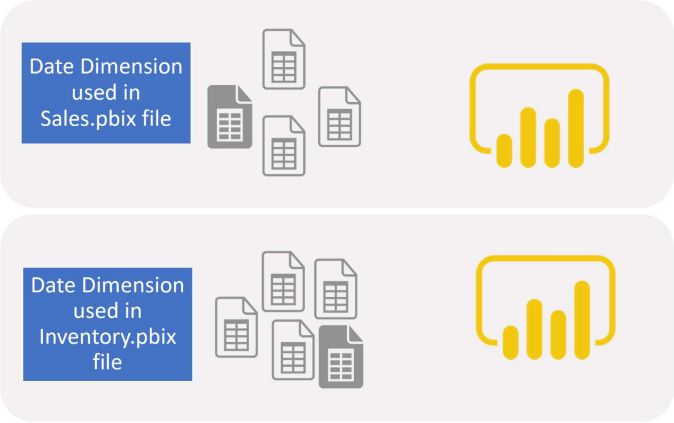
- Multiple developers cannot work on one PBIX file at the same time. Multi-Developer issue.
- It would be very hard to integrate the single PBIX file with another application or dataset. High Maintenance issue.
- All data transformations are happening inside the model, and the refresh time would be slower.
- The only way to expand visualization would be adding pages to the model, and you will end up with hundreds of visualization pages after some time.
- Every single change, even small change in the visualization, means deploying the entire model for every single change.
- Creating a separate Power BI file with some parts of it referencing from this model would not be possible, as a result, you would need to do a lot of duplicates, and high maintenance issue again.
- and many other issues.

72

Using a Query in multiple Files?

73

Using One Power Query Table in Multiple Power BI Reports



Date Dimension transformation executed multiple times, when only once is needed

74

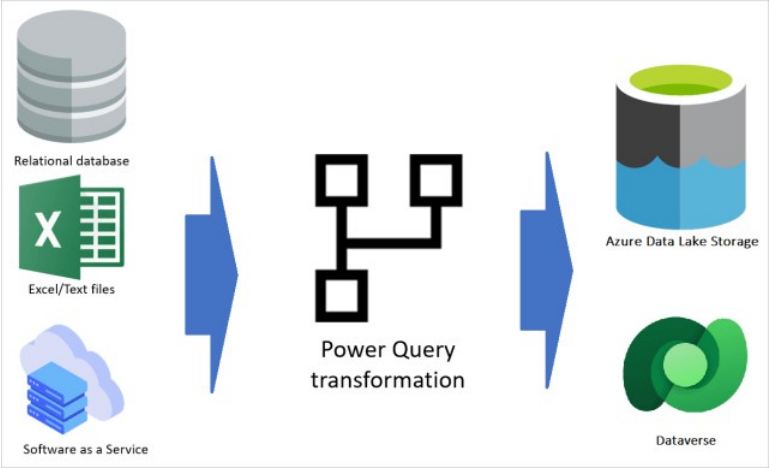
The Solution

Dataflow for Transformation

75

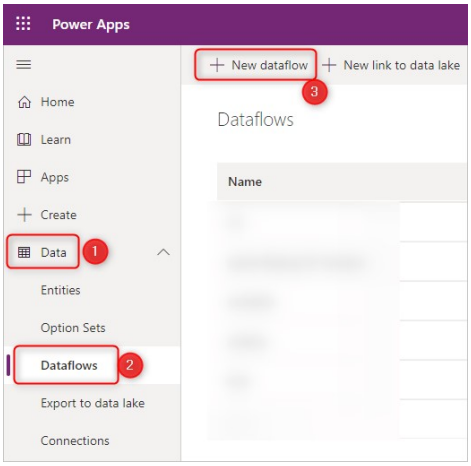
What is Dataflow?

Dataflow is a **Power Query** process that runs in the **cloud independently** from any Power BI reports.



76

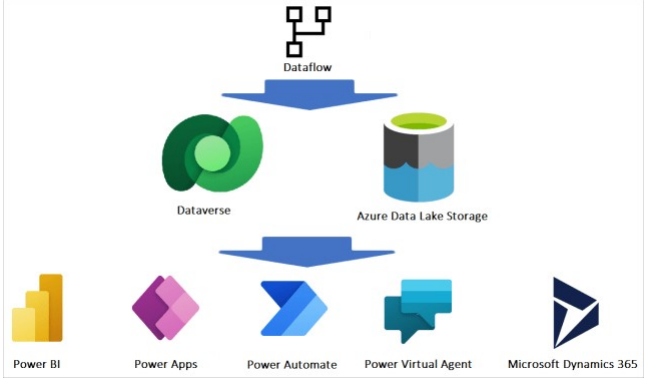
Not just for Power BI



77

Where is the Data Stored?

Dataflow stores the data in the Azure Data Lake storage or Dataverse.



78

Comes in two types

- Standard Dataflows
- Analytical Dataflows

OPERATION	STANDARD	ANALYTICAL
How to create	Power Platform dataflows	Power BI dataflows Power Platform dataflows by selecting the **Analytical Entity** checkbox when creating the dataflow
Storage options	Dataverse	Power BI provided Azure Data Lake Storage for Power BI dataflows, Dataverse provided Azure Data Lake Storage for Power Platform dataflows, or customer provided Azure Data Lake storage
Power Query transformations	Yes	Yes
AI functions	No	Yes
Computed entity	No	Yes
Can be used in other applications	Yes, through Dataverse	Power BI dataflows: Only in Power BI Power Platform dataflows or Power BI external dataflows: Yes, through Azure Data Lake Storage
Mapping to standard Entity	Yes	Yes
Incremental load	Default incremental-load Possible to change using the **Delete rows that no longer exist in the query output** checkbox at the load settings	Default full-load Possible to set up incremental refresh by setting up the incremental refresh in the dataflow settings
Scheduled Refresh	Yes	Yes, the possibility of notifying the dataflow owners upon the failure

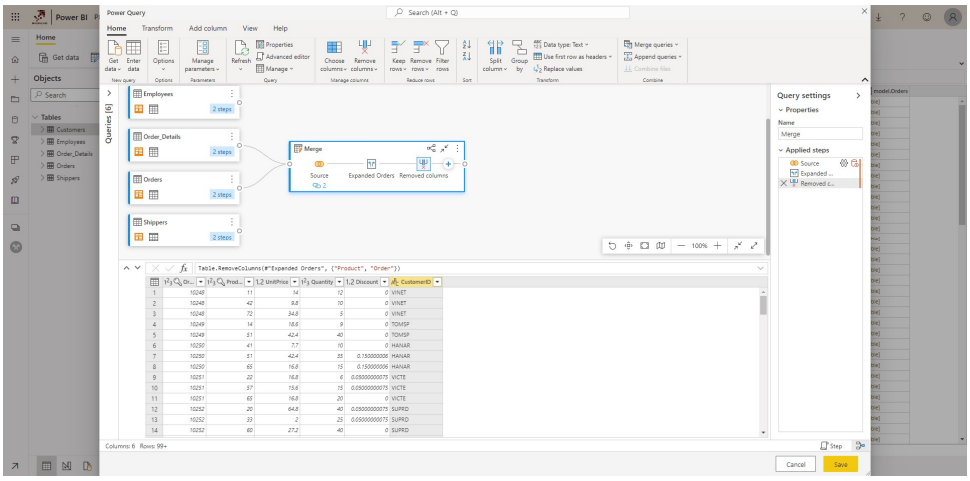
79

Comes in two editions

- Dataflow Gen1 (Power BI only)
- Dataflow Gen2 (Fabric)
  - Includes destinations (such as Azure SQL DB, Lakehouse …)

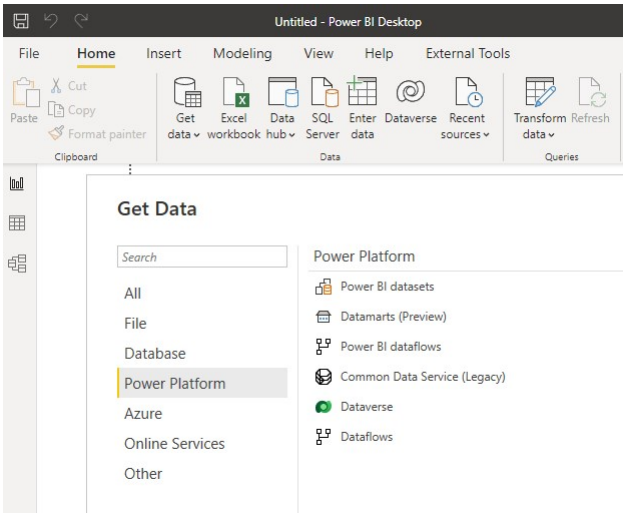
80

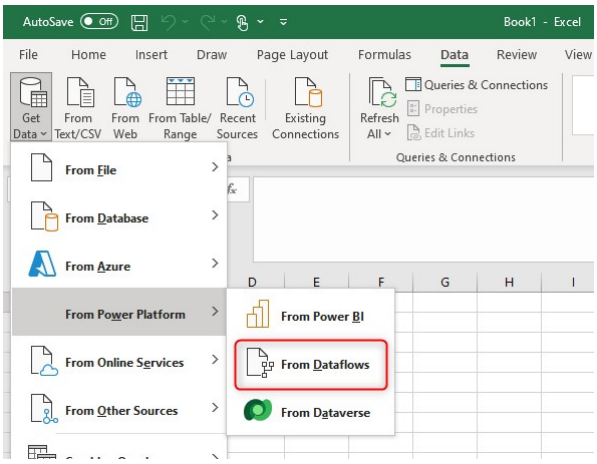
Power Query Online engine



81

Get Data from Dataflow

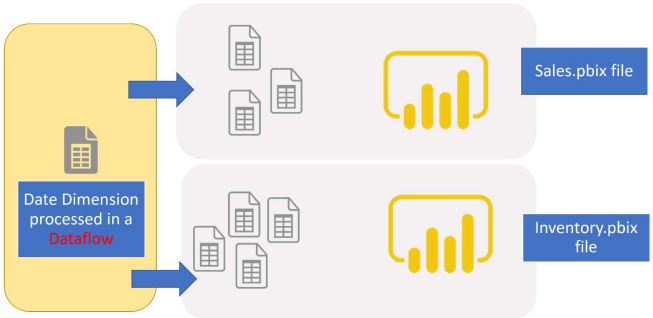




82

Using One Power Query Table in Multiple Power BI Reports

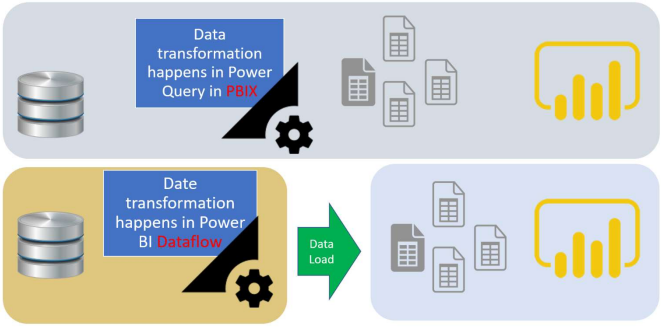
- Re-usable tables or queries across multiple Power BI files, are one of the best candidates for Dataflow.



Date Dimension transformation executed only once, and then used multiple times

83

FASTER refresh time

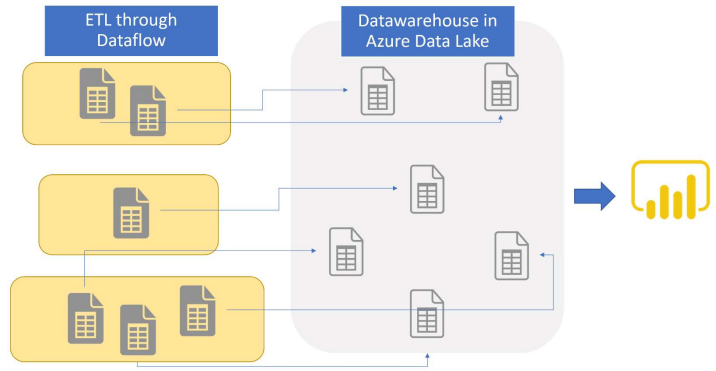


Push heavy transformations to Power BI dataflow

84

Centralized Data Warehouse

- Dataflow can be the ETL engine, that fuels the centralized data warehouse in Azure data lake storage.

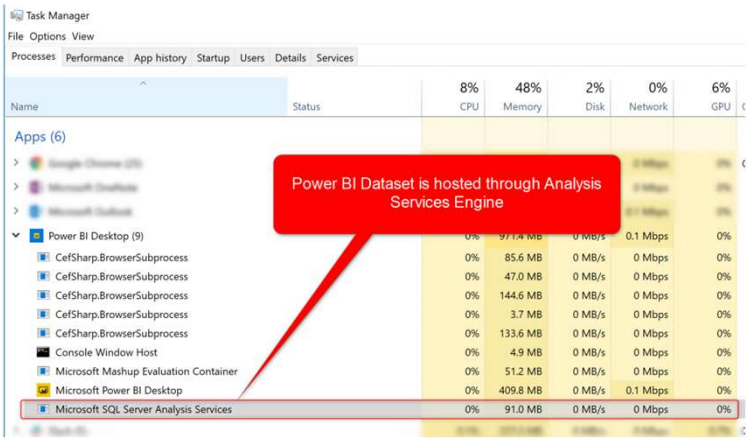


Dataflow Fuels the Azure Data Lake as the ETL fuels the Data Warehouse

85

Sematic Model (Shared Dataset)

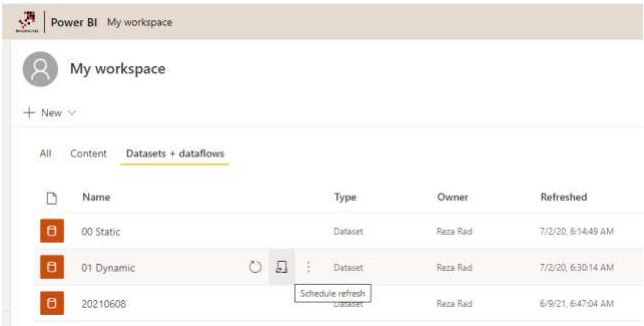
86



- The **report** is the visualization layer of your Power BI implementation
- The **dataset** includes the data, tables, relationships, calculations, and connection to the data source.

What is the Sematic Model?

87



Semantic Model in the Service

88

Using a Calculation (DAX) in multiple files?

89

The Solution

Shared dataset

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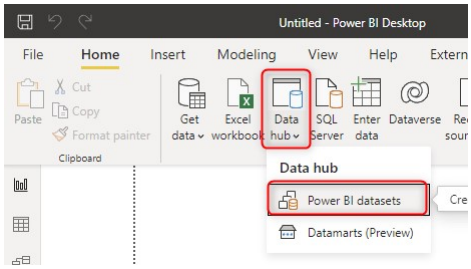
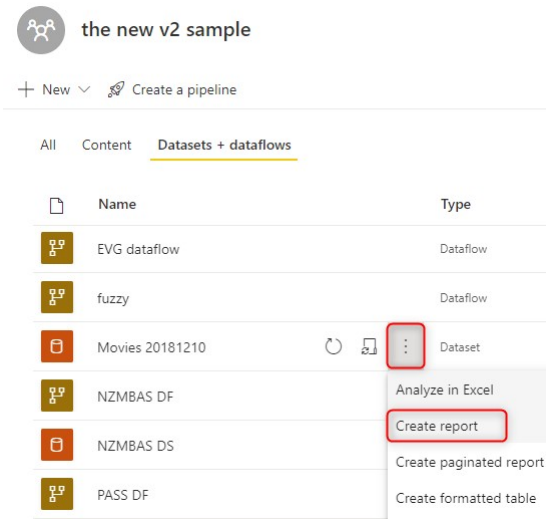
Shared Dataset

Dataset used in multiple reports





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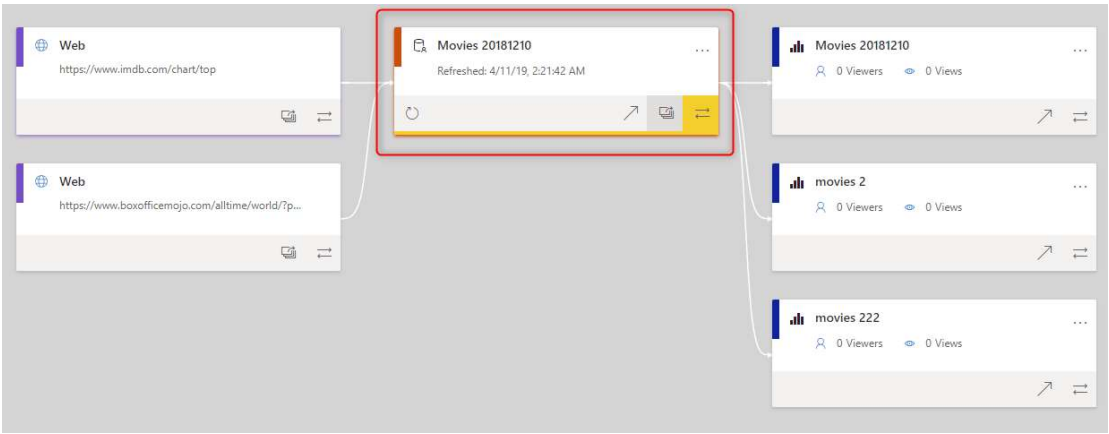
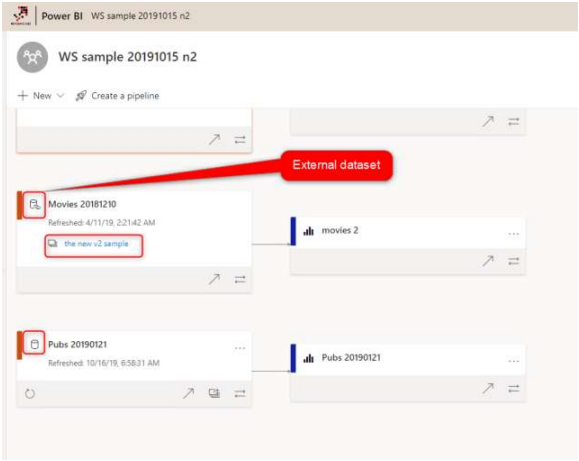
Shared Dataset Lineage



92

Across multiple workspaces



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Datamart

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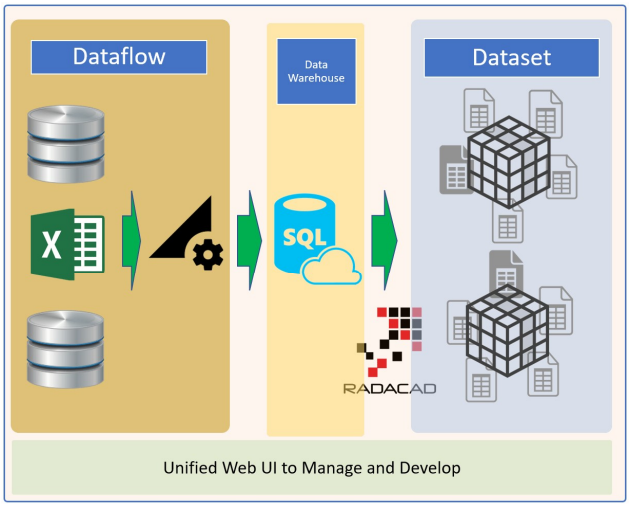
What is Power BI Datamart?



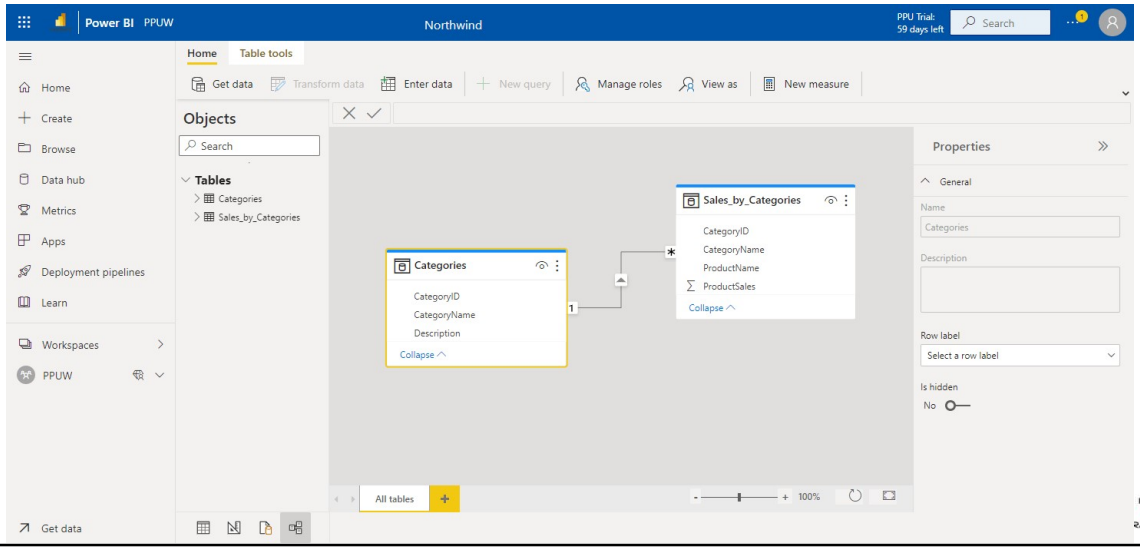
Power BI Datamart

95

What are the features of Datamart that empowers Power BI development?

96

One Place to Manage and Build, No Other Tools Needed



97

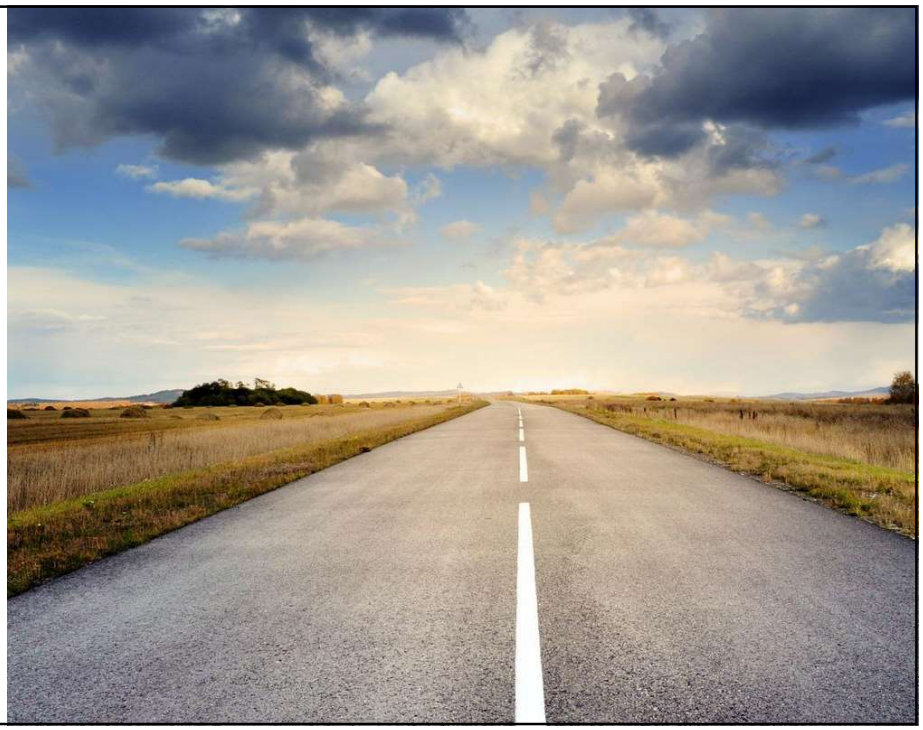
One license is enough

- Premium capacity
- Premium Per User (PPU)

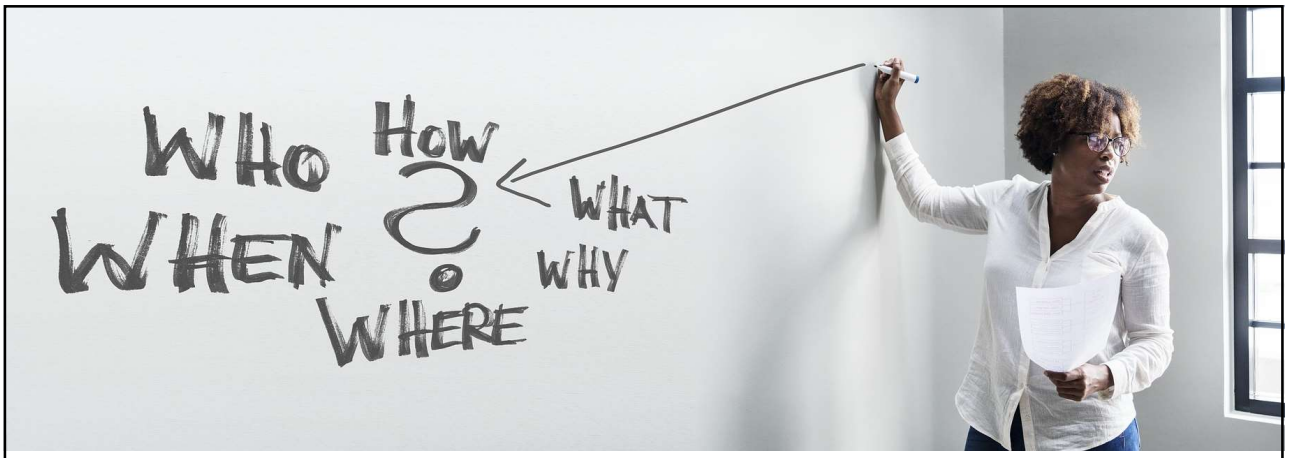
98

The vast horizon in the future of Datamart

- Slowly changing dimension (SCD)
- Inferred Dimension Member
- Log and monitor of dataflow
- Multi-developer environment
- Version control
- …



99



Who the Datamart is for?

100

Three sample Datamart users

- Power BI Datamart for Citizen Data Analyst
- Power BI Datamart for Enterprises
- Power BI Datamart for Developers

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The Multi-Layered Architecture

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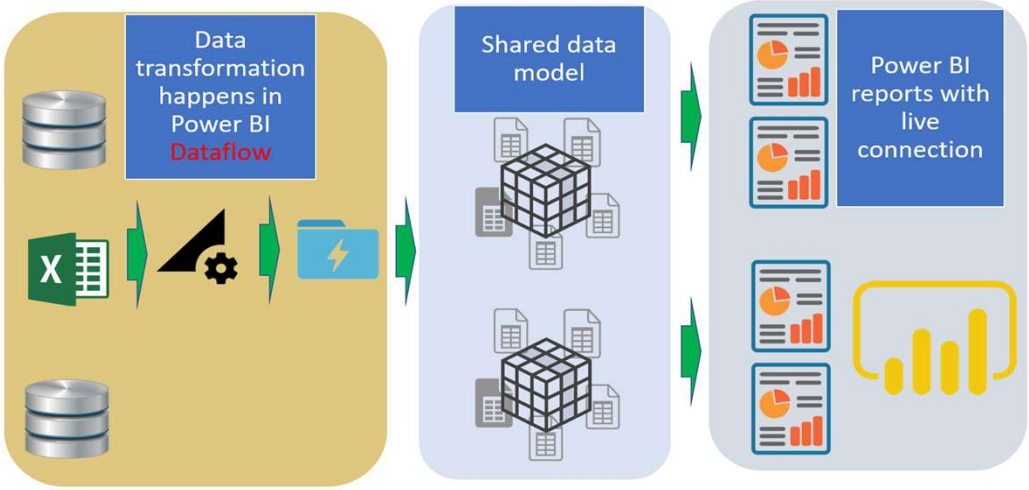
Power BI Architecture for Multi-Developer Tenant Using Dataflows and Shared Datasets



Power BI Solution Architecture

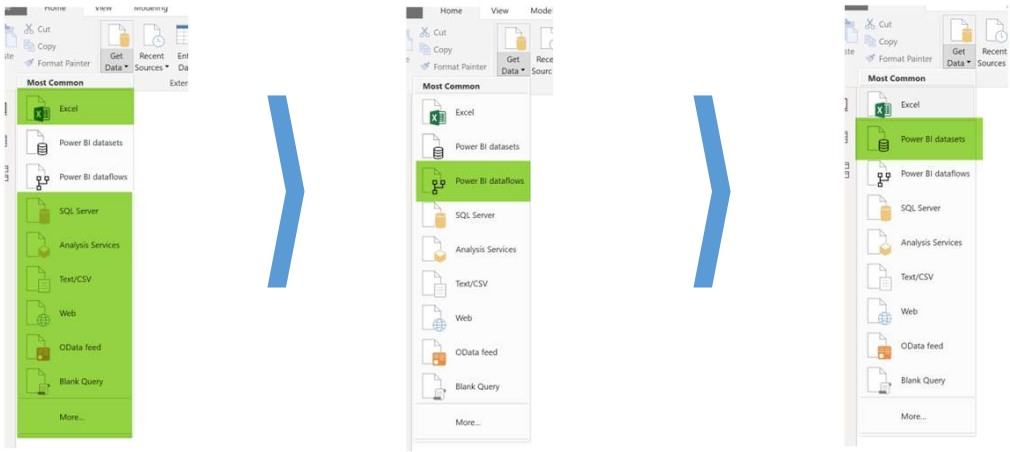
103

How to build these three layers

- Data Transformation

Data Modelling

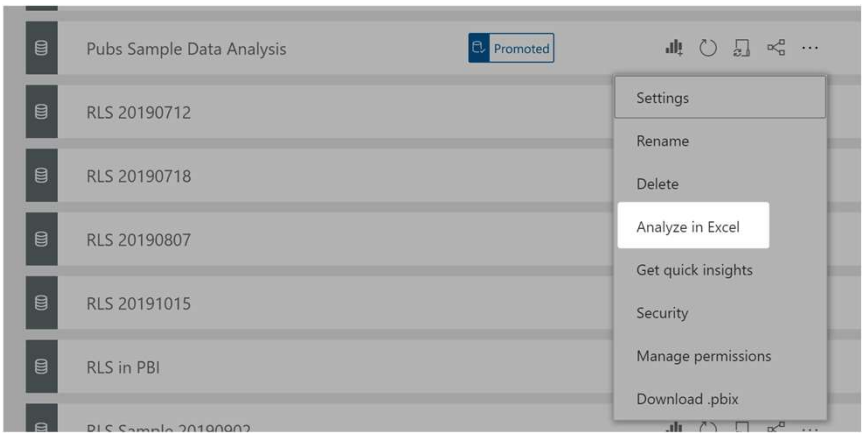
Data Visualization



104

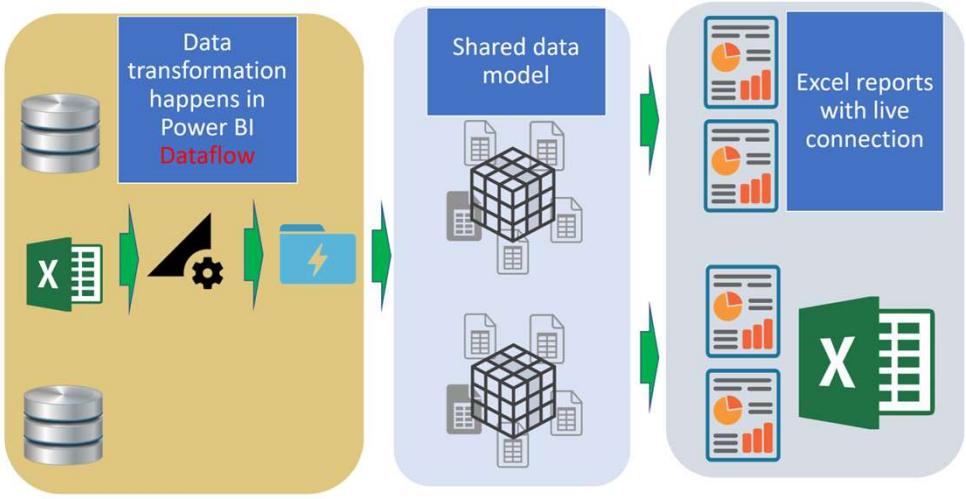
Excel Users: Analyze in Excel

- NO Export!



105

Power BI Architecture for Multi-Developer Tenant Using Dataflows and Shared Datasets



Power BI Solution Architecture

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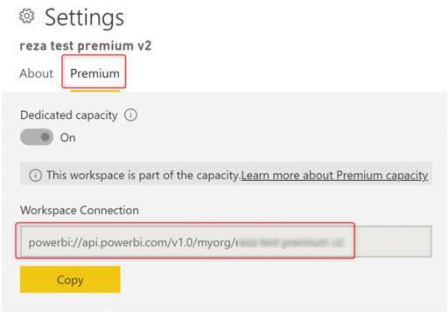
If you use other visualization tools!

- No Problem, we got your back.
- Power BI covers the limitations of Tableau 😉 😁



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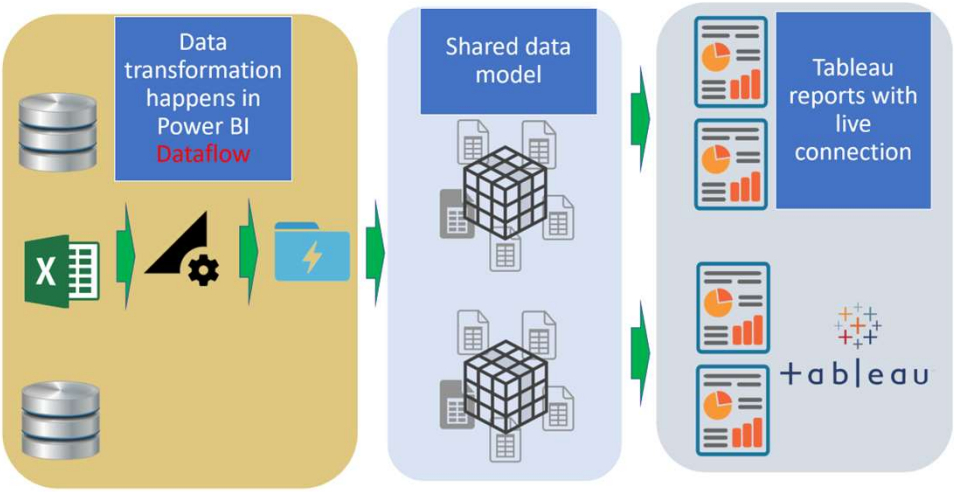
Power BI Architecture for Multi-Developer Tenant Using Dataflows and Shared Datasets

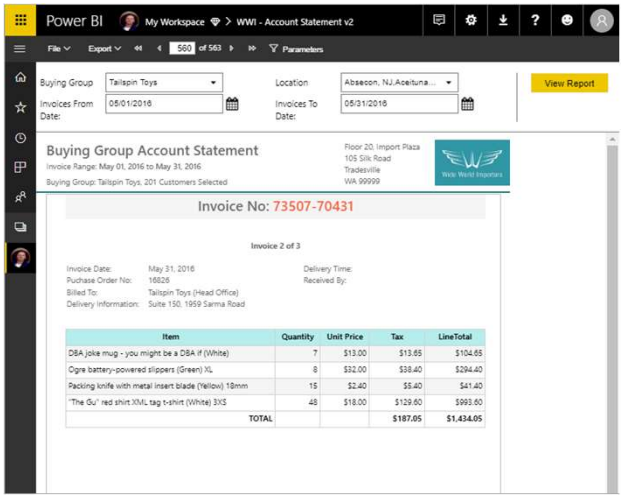


Power BI Solution Architecture (Premium)

108

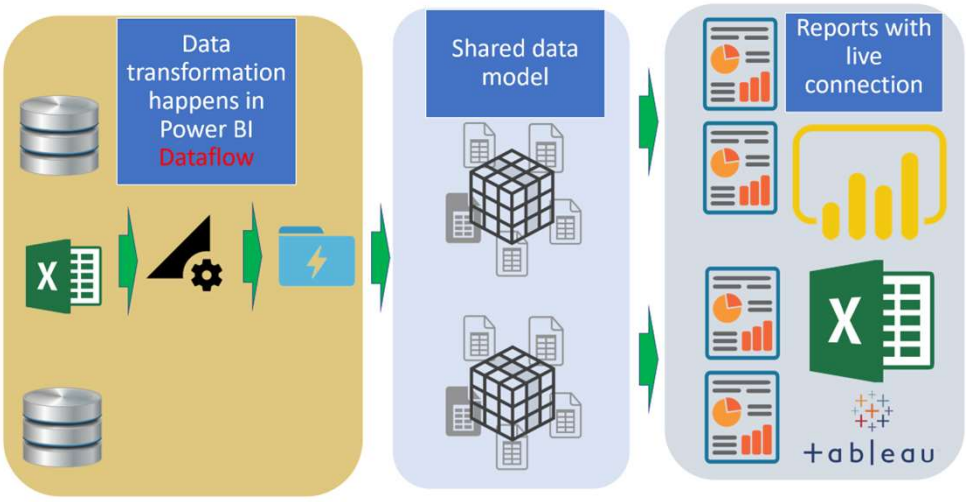
Paginated Reports

- Build for printing, export to PDF, paginated…



109

Power BI Architecture for Multi-Developer Tenant Using Dataflows and Shared Datasets



Power BI Solution Architecture

110

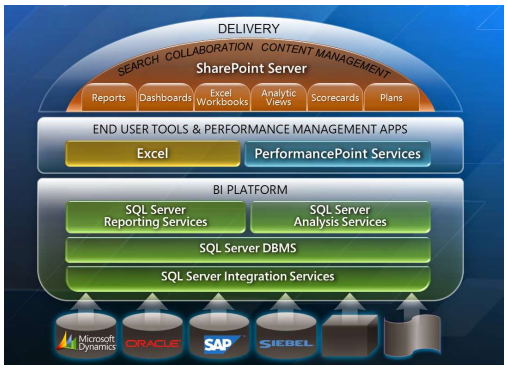
Benefits of this architecture

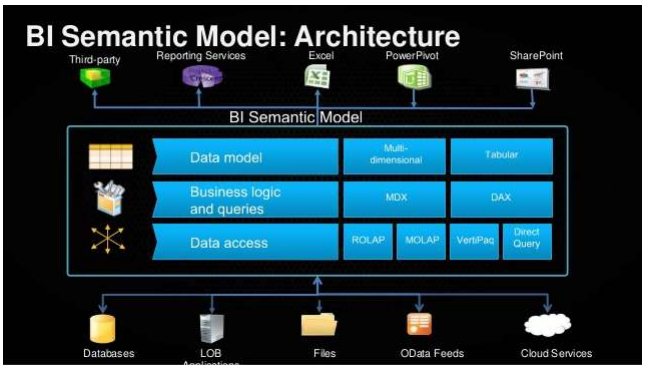
- Decoupling Data preparation, Modelling, Visualization
- Faster Refresh Time for Power BI model
- Dataflow is not a core developer tool
- Multi-Developer Environment
- Re-use of Calculations and Modeling

111

This Architecture is Not New

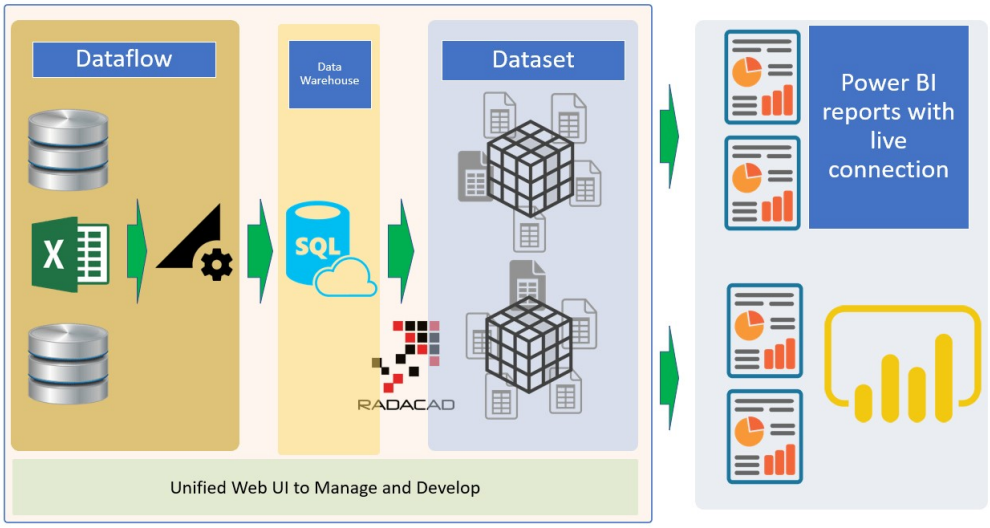
- Re-using best practices from traditional BI system
- Removing problematic blocks





112

The Architecture with Datamart



Power BI Solution Architecture using Datamart

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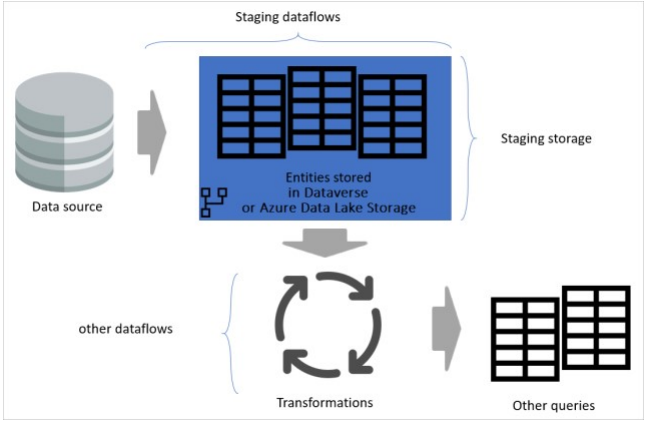
Staging Dataflow



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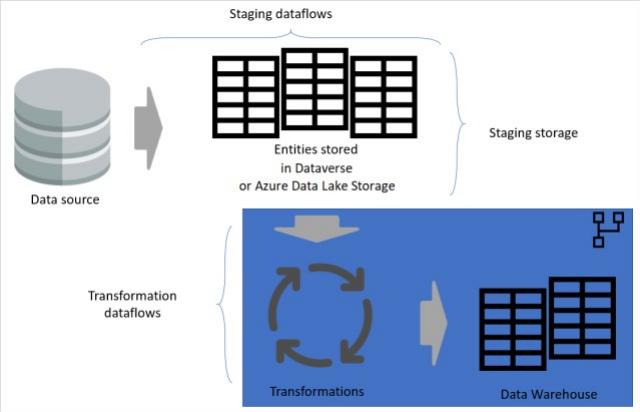
Transformation Dataflow



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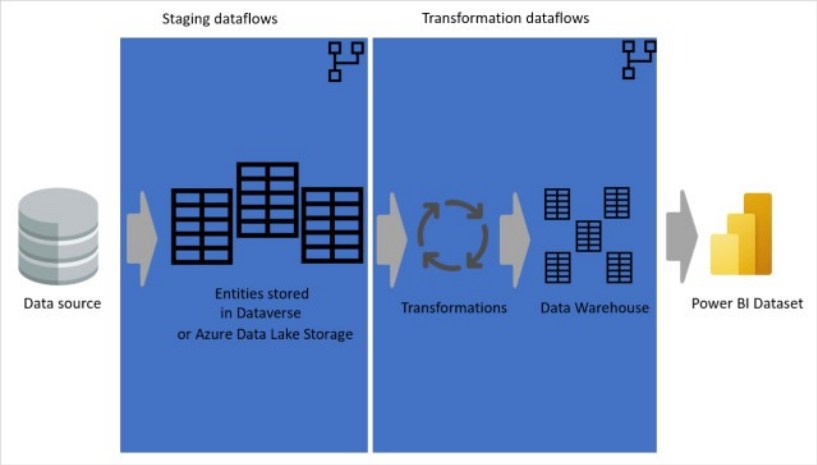
Layered Dataflow Design



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Chained Dataset

DQ Connection to Power BI datasets

- Leverage the central model
- Bring more datasets
- Self-service and enterprise model combined
- Less redundancy
- More consistency
- Re-use instead of re-do
- More trust in Power BI results

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Dataflow Vs. Dataset Vs. Datamart

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Dataflow Vs. Dataset

Dataflow	Dataset
Replacement of your Power Query layer	Replacement of your modeling, relationship, DAX expressions
ETL Layer	Modeling Layer
Feeds Data to the Dataset	Feeds the Visualization Layer
Access the data source directly (usually)	Access the data from dataflow (best practice)
Dataflow developer needs to have Power Query skills	Dataset developer needs DAX and modelling skills
Users of dataflow are data modelers	Users of dataset are report visualizers
Dataflow solves the problem of having multiple version of the same table in different PBIX files	Dataset solves the problem of having multiple version of the same DAX code in different PBIX files

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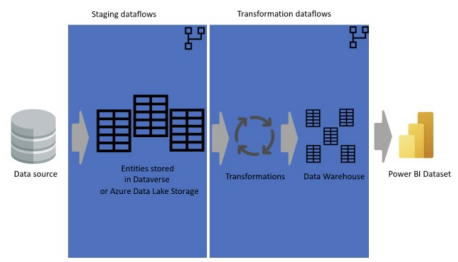
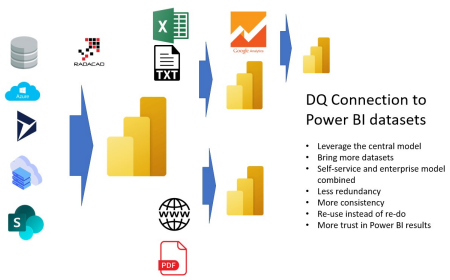
Datamart

- Replacing Dataflow?
- Replacing Dataset?





120

Paginated Reports

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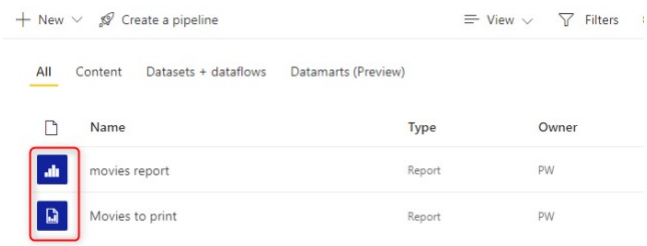
Two types of reports in the service



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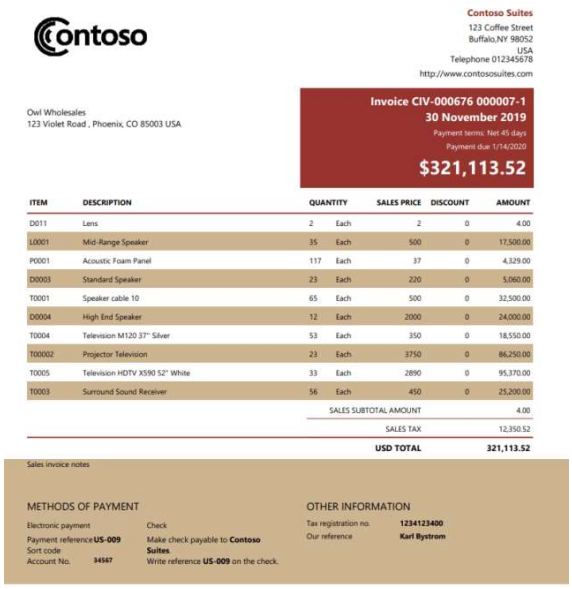
Sample paginated report



Contoso

Contoso Suites
123 Coffee Street
Buffalo,NY 98052
USA
Telephone 012345678
http://www.contososuites.com

Owl Wholesales
123 Violet Road , Phoenix, CO 85003 USA

Invoice CIV-000676 000007-1
30 November 2019
Payment terms: Net 45 days
Payment due 1/14/2020
$321,113.52

ITEM	DESCRIPTION	QUANTITY		SALES PRICE	DISCOUNT	AMOUNT
D011	Lens	2	Each	2	0	4.00
L0001	Mid-Range Speaker	35	Each	500	0	17,500.00
P0001	Acoustic Foam Panel	117	Each	37	0	4,329.00
D0003	Standard Speaker	23	Each	220	0	5,060.00
T0001	Speaker cable 10	65	Each	500	0	32,500.00
D0004	High End Speaker	12	Each	2000	0	24,000.00
T0004	Television M120 37" Silver	53	Each	350	0	18,550.00
T00002	Projector Television	23	Each	3750	0	86,250.00
T0005	Television HDTV X590 52" White	33	Each	2890	0	95,370.00
T0003	Surround Sound Receiver	56	Each	450	0	25,200.00
			SALES SUBTOTAL AMOUNT			4.00
				SALES TAX		12,350.52
				USD TOTAL		321,113.52

Sales invoice notes

METHODS OF PAYMENT

Electronic payment
Payment reference **US-009**
Sort code
Account No. **34567**

Check
Make check payable to **Contoso Suites**
Write reference **US-009** on the check.

OTHER INFORMATION

Tax registration no. **1234123400**
Our reference **Karl Bystrom**

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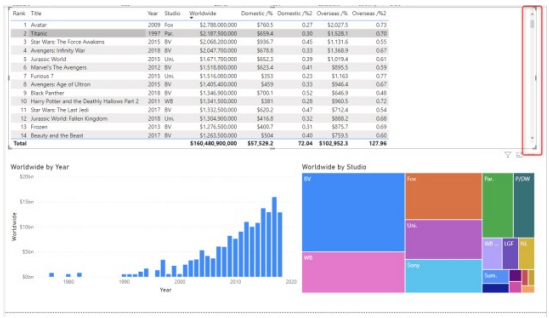
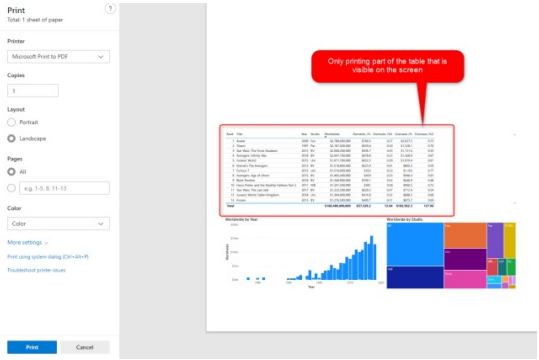
123

Why paginated reports?

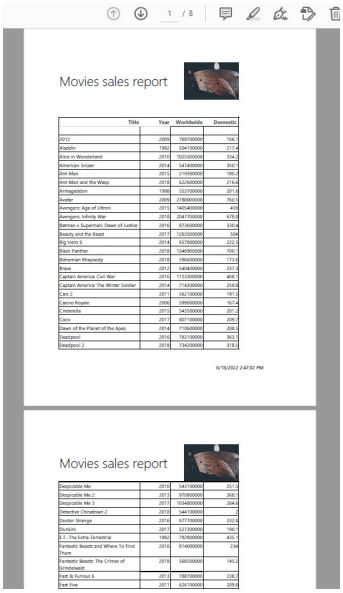




RADACAD

124

Paginated report for printing



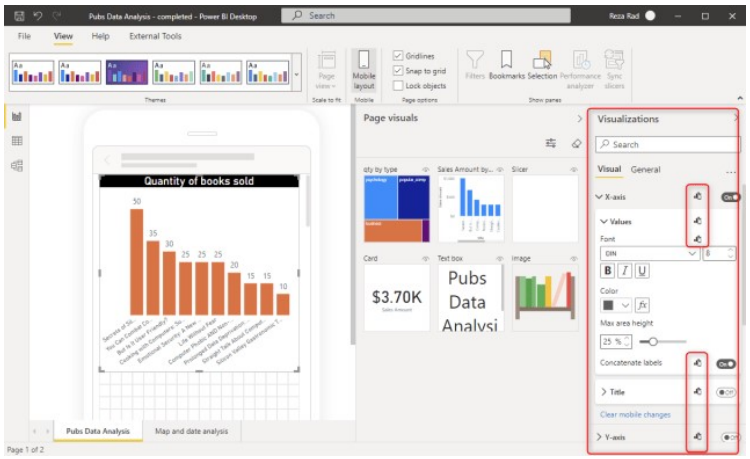
125

Power BI Paginated Report Vs Power BI Report

	POWER BI REPORT	PAGINATED REPORT
It can be created using	Power BI Desktop Power BI Service	Power BI Report Builder Visual Studio
License needed	Power BI Free, Pro, Premium, PPU	Premium, PPU
Ideal for	Interactive analytical reports	Pixel-perfect print-ready reports
Design Process	Powerful and user-friendly GUI of Power BI Desktop	Powerful but not much user-friendly (more developer-focused) UI of Report Builder or Visual Studio
File extension	.PBIX	.RDL

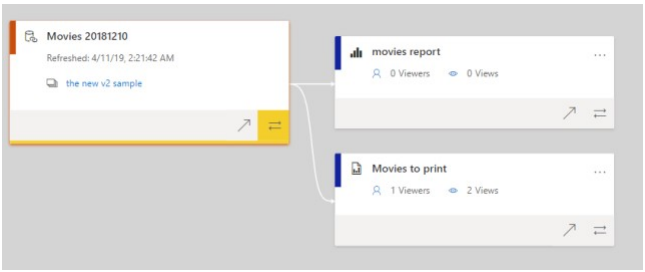
126

Think Twice; Do you need a paginated report?



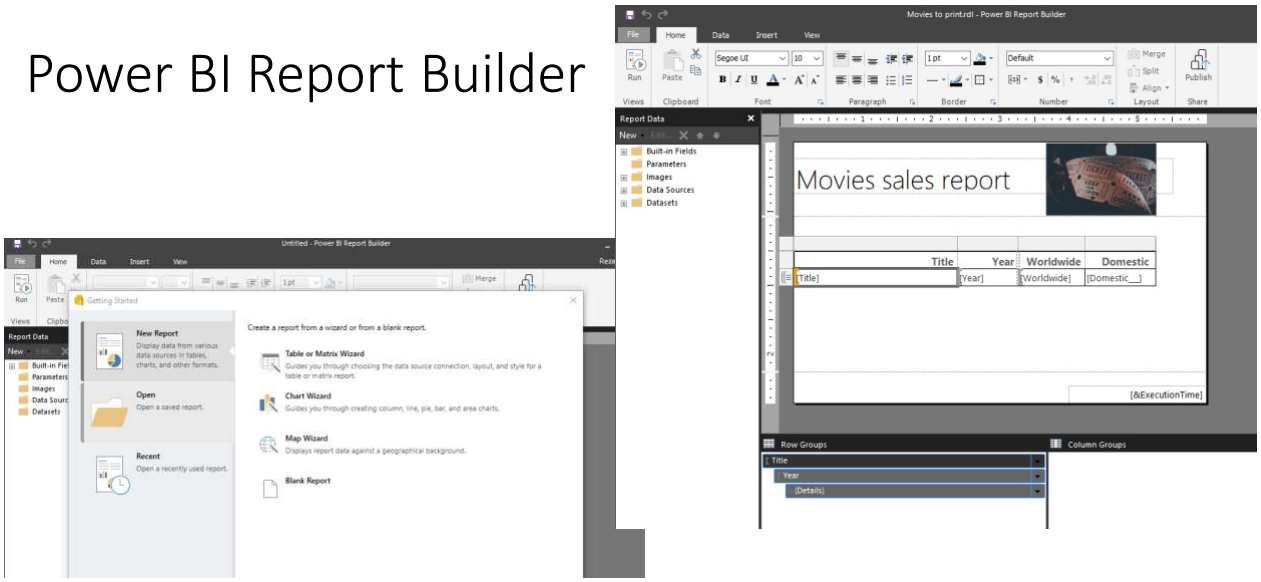
127

Use one dataset



128

Power BI Report Builder

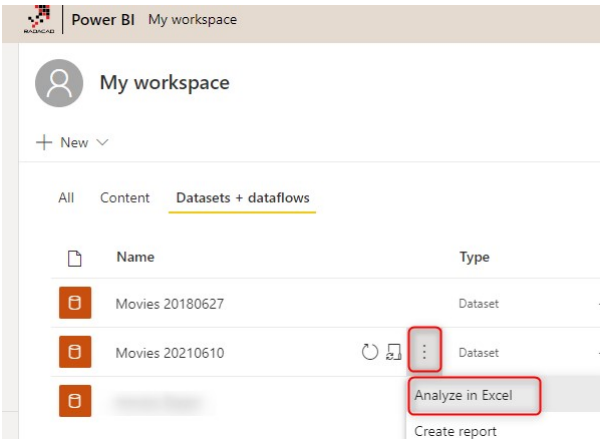


129

Excel and Power BI

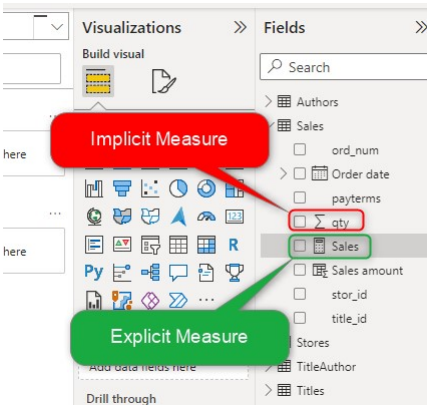
130

Analyze in Excel



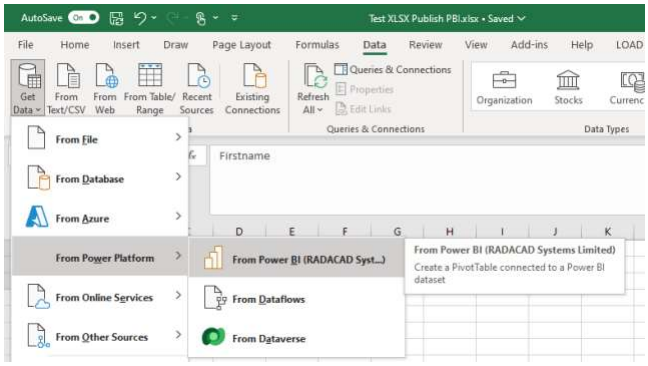
131

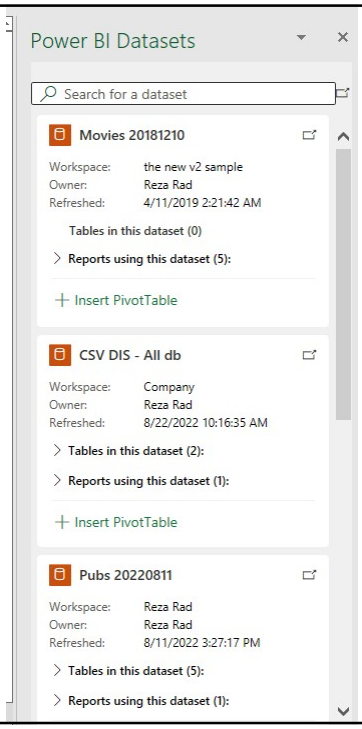
Implicit Vs. Explicit Measures



132

Get data from Power BI Dataset





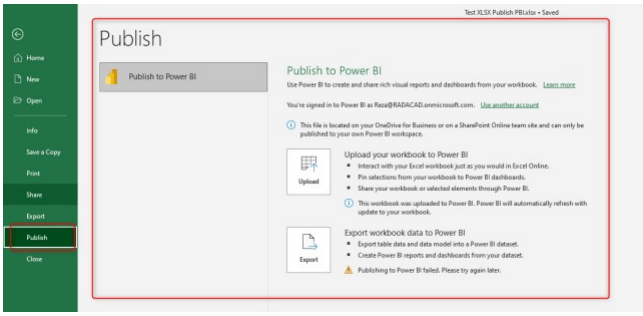
133

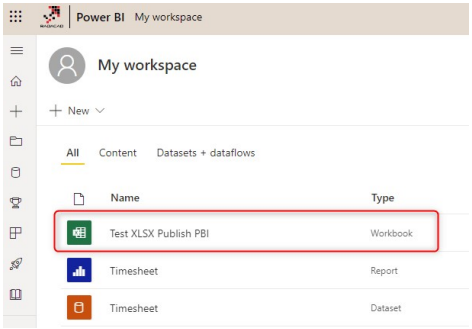
Yes to Analyze in Excel, No to Export Data

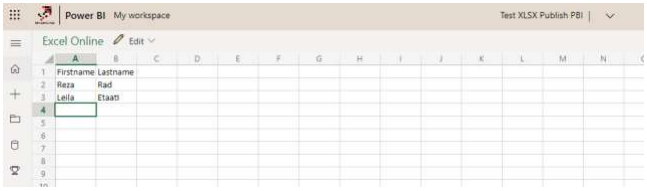
- Analyze in Excel is Live Connection, Export Data is Offline, outdated
- Export Data is limited to 150,000 Rows; analyze in Excel Not!
- Export Data is limited to specific visuals and fields used in that visual
- Export Data is not Secure. Analyze in Excel uses Power BI account credentials.
- Analyze in Excel supports Row-Level Security.
- Analyze in Excel uses the concept of Shared Datasets

134

Publish to Power BI from Excel







135

Real-time streaming Dataset

136

Real-time Vs. Live or DirectQuery

- In a Live Connection or DirectQuery connection report or dashboard; anytime you REFRESH the visual (which can be done either by refreshing the report itself or by clicking on a visual or slicer that triggers a query from the data source), you get the most up-to-date data. The report or dashboard can also be SCHEDULED to refresh automatically so that you have the most up-to-date data every 15 minutes (or whatever your scheduled frequency set up is).
- A real-time dashboard will update automatically as soon as the new data row appears in the dataset. This new data row can come from various methods, such as pushing through REST API of Power BI, Stream Analytics or other streaming services such as PubNub. A real-time dashboard does not need a scheduled refresh.

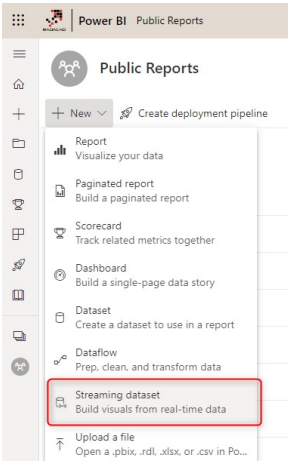
137

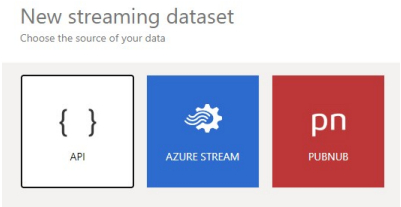
Sample Scenario

- A Microsoft Form is shared with users to get feedback on their Power BI roles and salaries.
- Power Automate is used to pass the feedback posted in the form (as soon as it arrives) to the Power BI streaming dataset.
- Power BI streaming dataset is receiving the feedback and presenting it in real-time on a dashboard.

138

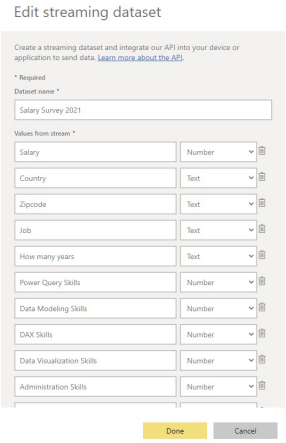
Streaming Dataset is a service-only object

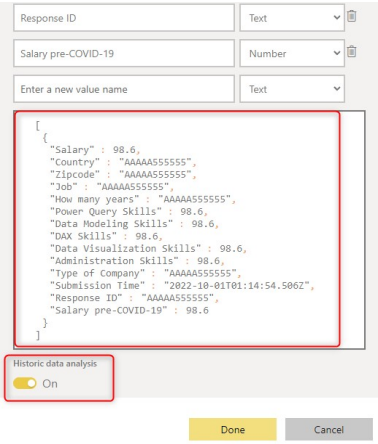




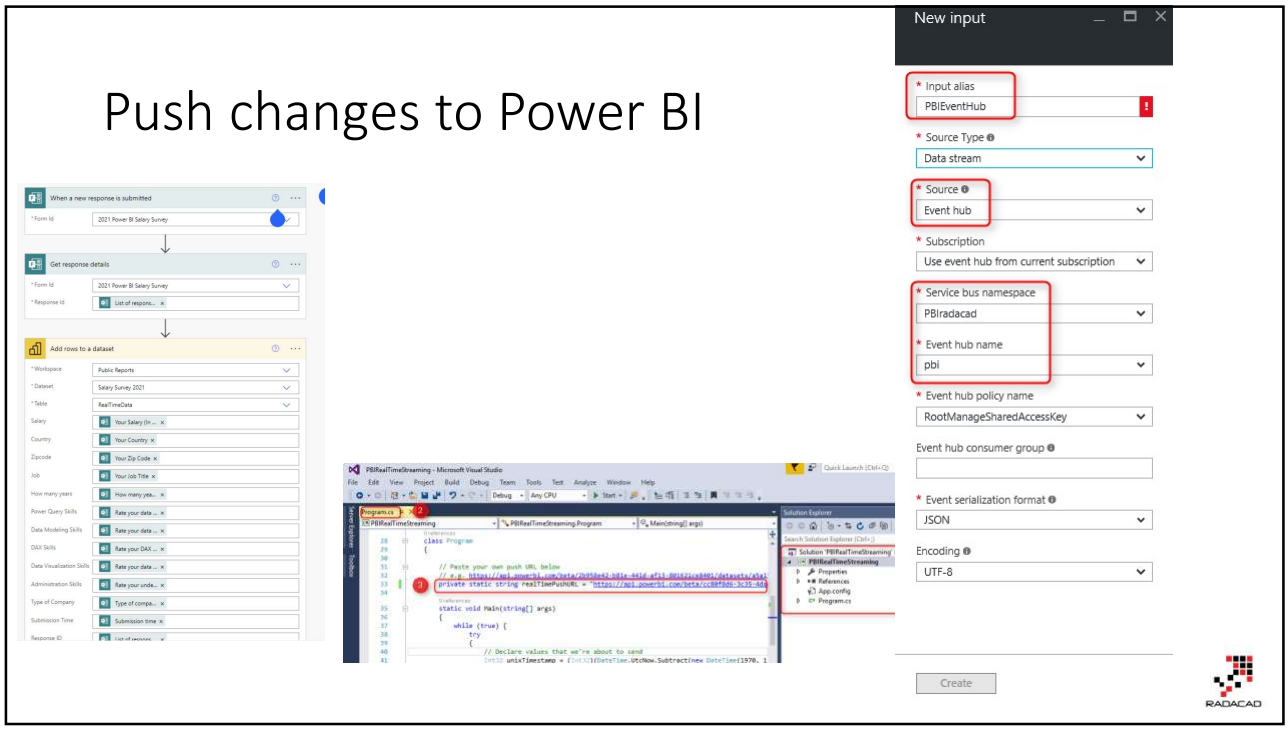
139

Building the Dataset in the service





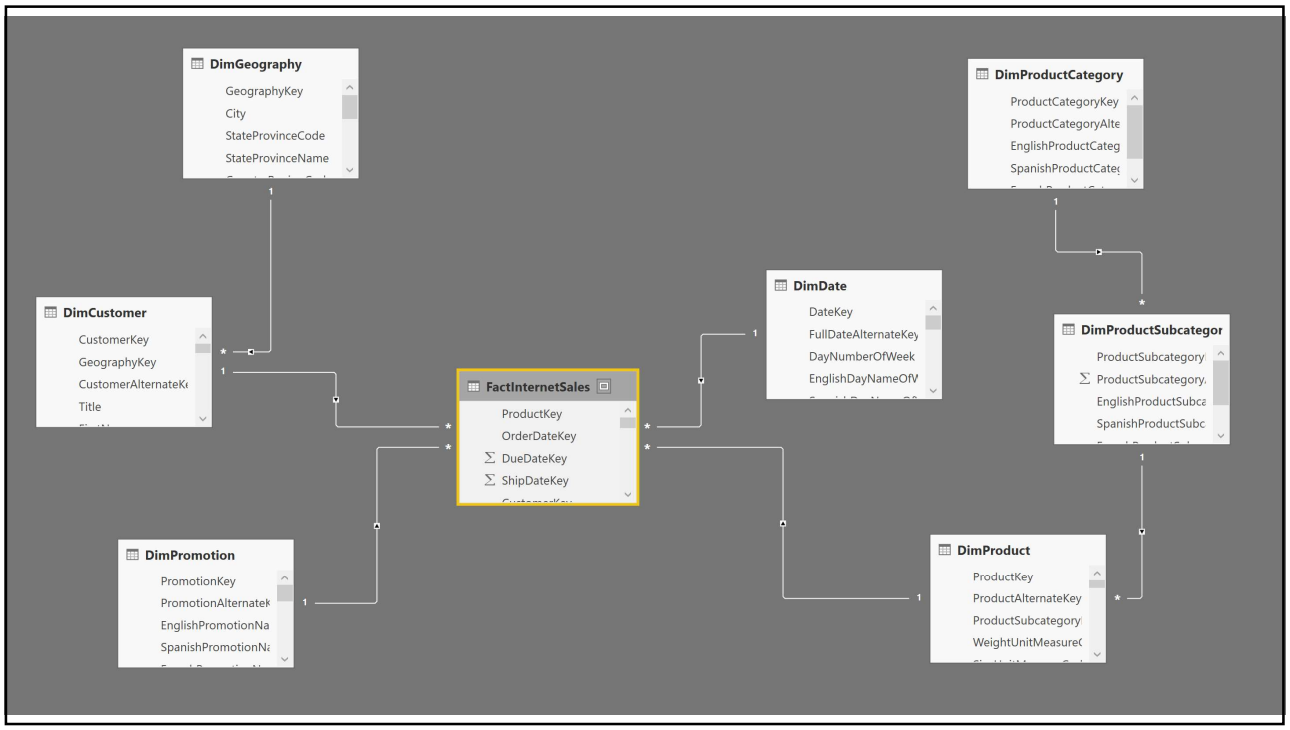
140


Push changes to Power BI
New input
* Input alias
PBIEventHub
* Source Type
Data stream
* Source
Event hub
* Subscription
Use event hub from current subscription
* Service bus namespace
PBIradacad
* Event hub name
pbi
* Event hub policy name
RootManageSharedAccessKey
Event hub consumer group
* Event serialization format
JSON
Encoding
UTF-8
Create
RADACAD

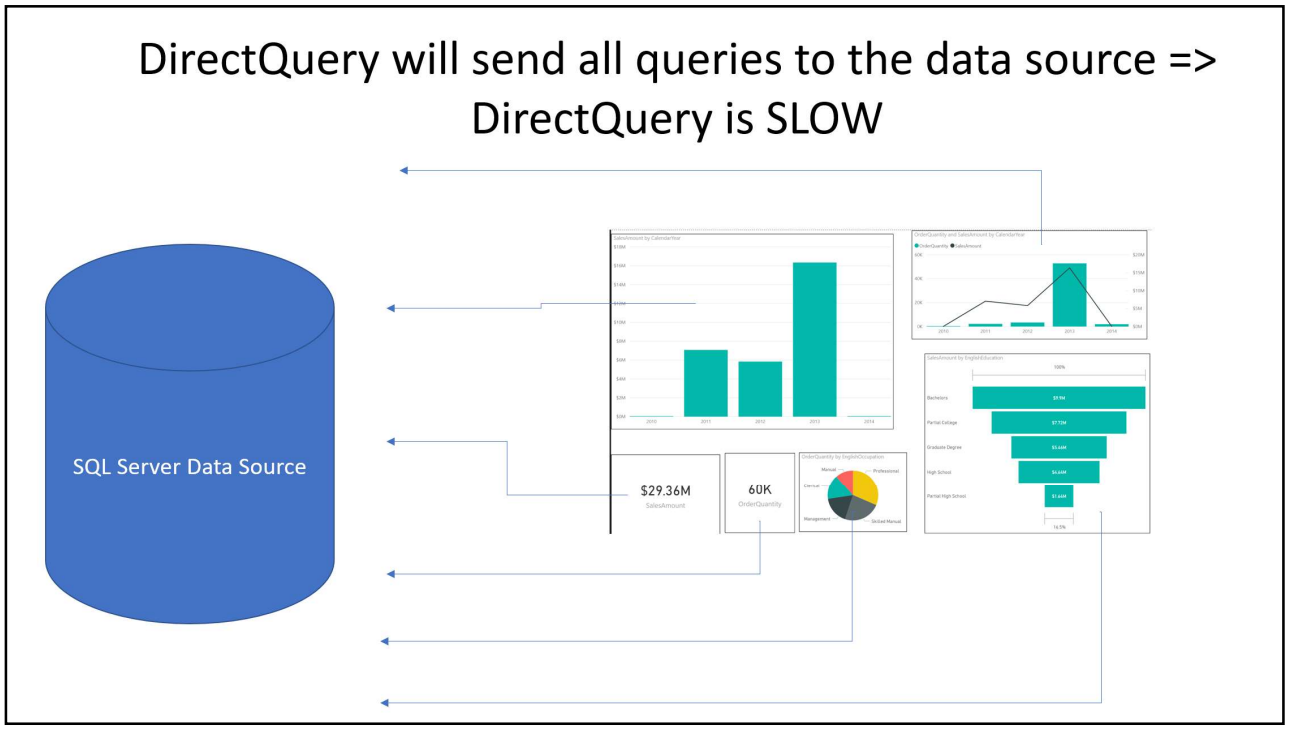
141

Power BI Fast and Furious with Aggregations
Queries will be answered by Aggregated tables if exists
SQL Server Data Source
In Memory Storage of Power BI

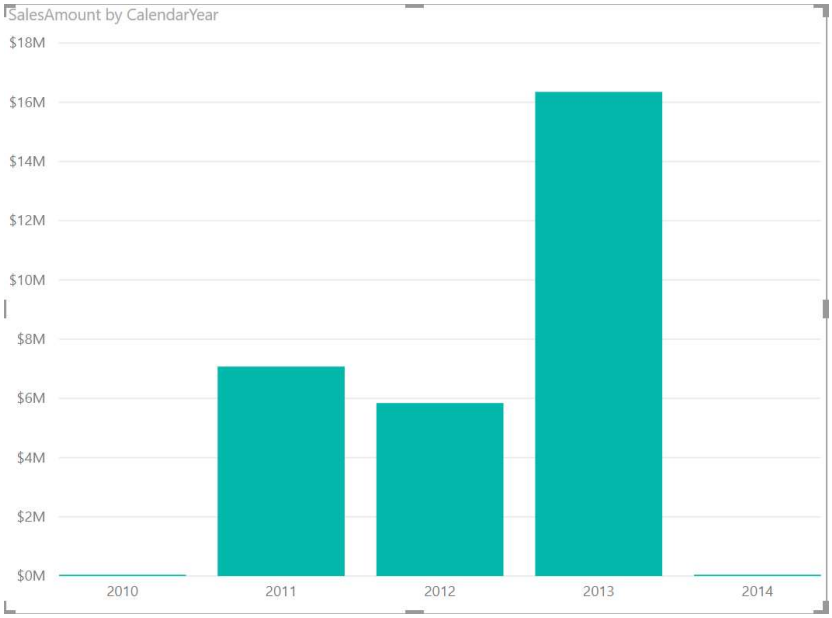
142


DimGeography
GeographyKey
City
StateProvinceCode
StateProvinceName
DimProductCategory
ProductCategoryKey
DimCustomer
CustomerKey
GeographyKey
Title
DimDate
DateKey
FullDateAlternateKey
DayNumberOfWeek
DimProductSubcategor
ProductSubcategory
EnglishProductSubca
SpanishProductSubc
FactInternetSales
ProductKey
OrderDateKey
DueDateKey
ShipDateKey
DimPromotion
PromotionKey
EnglishPromotionNa
SpanishPromotionNa
DimProduct
ProductKey
ProductAlternateKey
ProductSubcategory
WeightUnitMeasure(

143

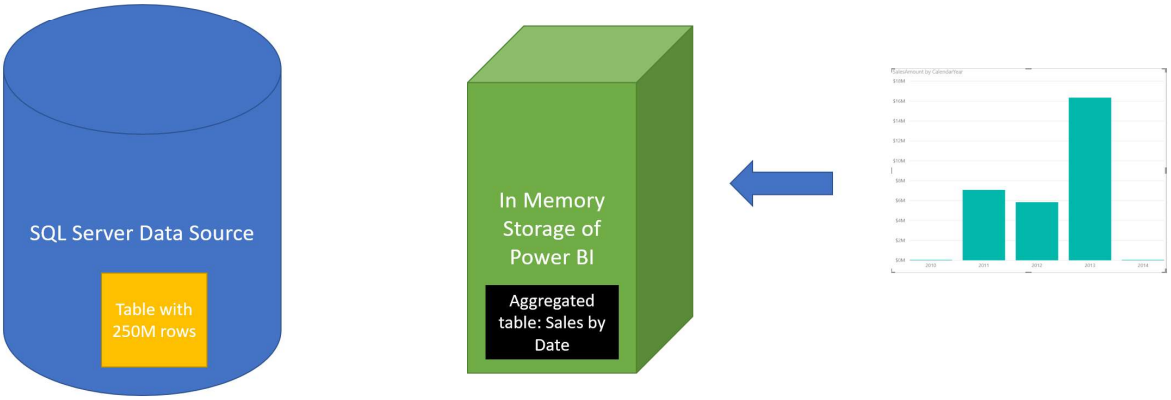

DirectQuery will send all queries to the data source => DirectQuery is SLOW
SQL Server Data Source
$29.36M
60K

144

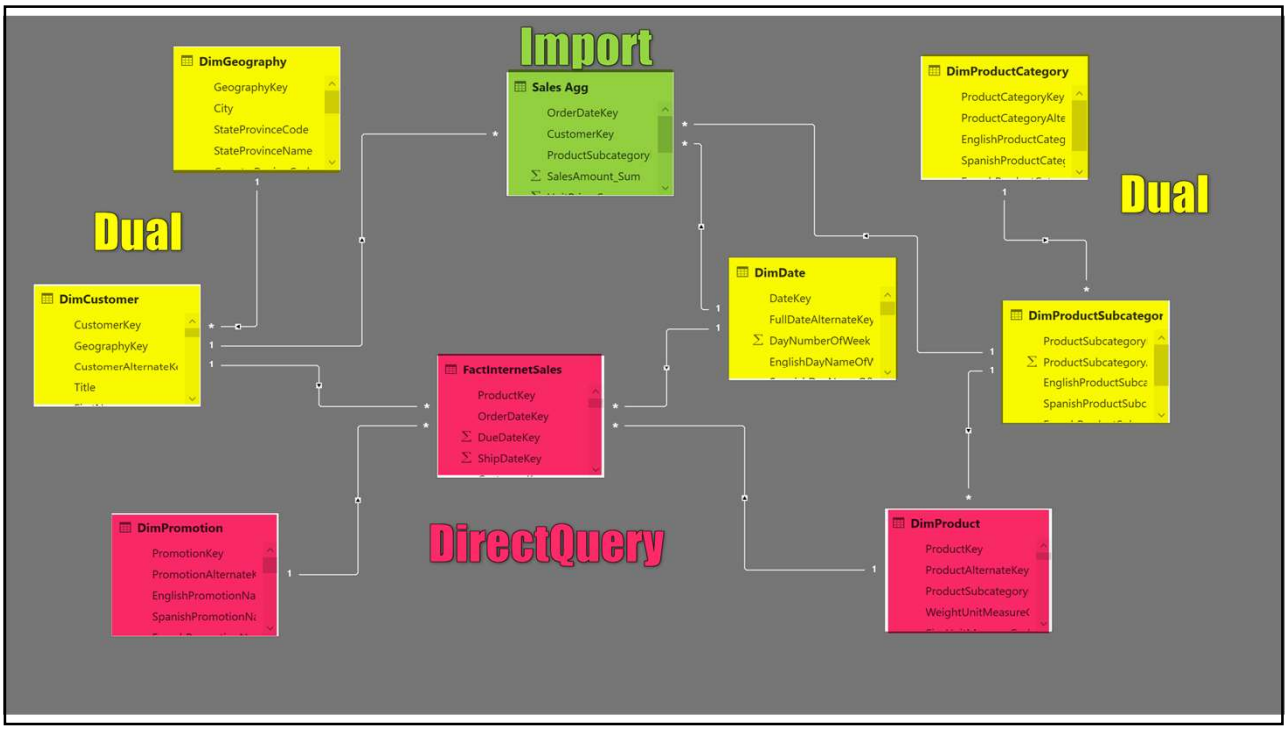


145

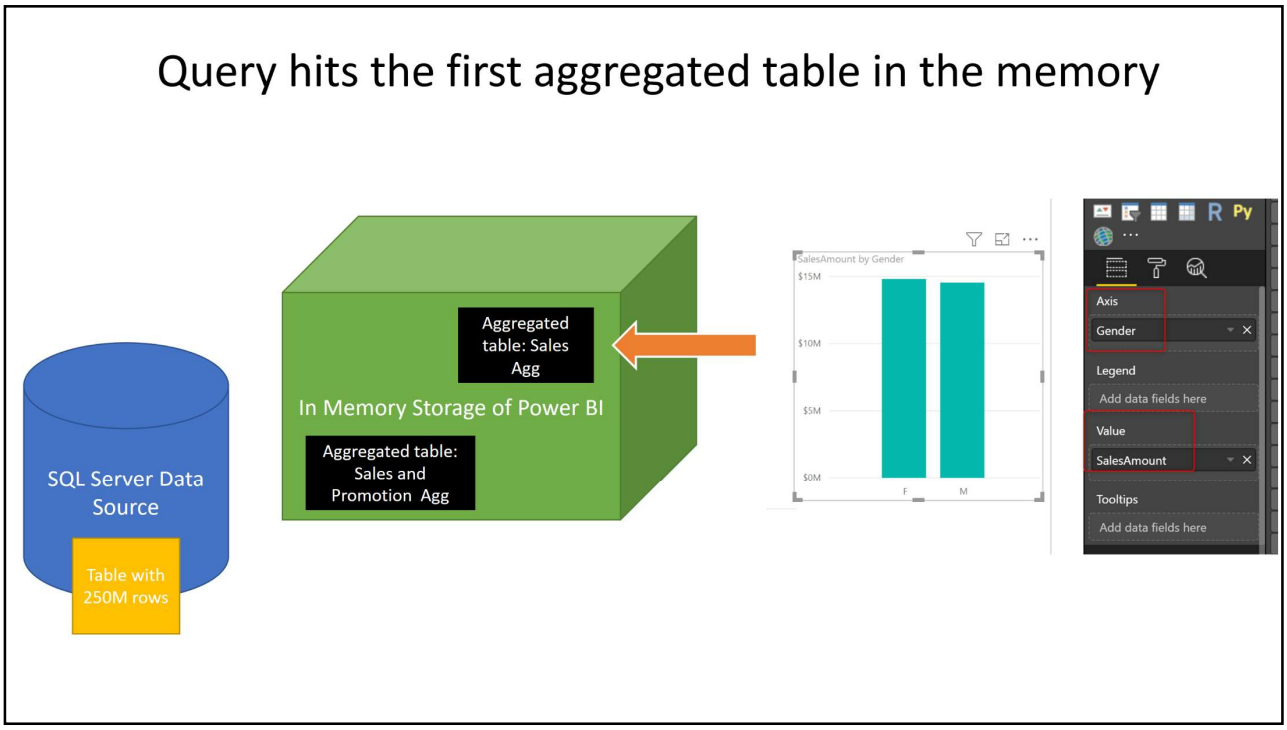
Sales by Year will hit the aggregated table in the memory



146

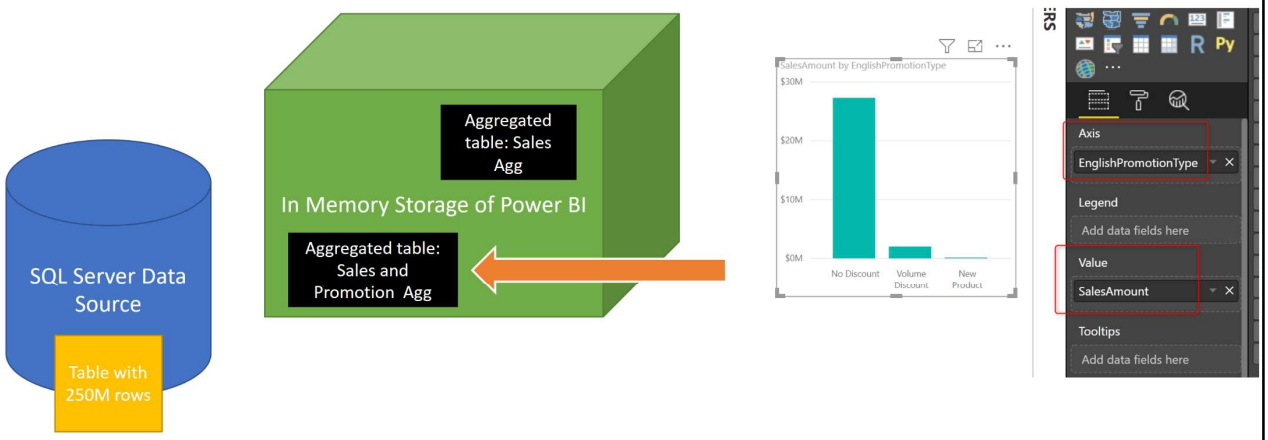

Import
Dual
Dual
DirectQuery
DimGeography
GeographyKey
City
StateProvinceCode
StateProvinceName
Sales Agg
OrderDateKey
CustomerKey
ProductSubcategory
SalesAmount_Sum
DimProductCategory
ProductCategoryKey
DimCustomer
CustomerKey
GeographyKey
Title
DimDate
DateKey
FullDateAlternateKey
DayNumberOfWeek
DimProductSubcategor
ProductSubcategory
FactInternetSales
ProductKey
OrderDateKey
DueDateKey
ShipDateKey
DimPromotion
PromotionKey
DimProduct
ProductKey
ProductAlternateKey
ProductSubcategory
WeightUnitMeasure

147


Query hits the first aggregated table in the memory
SQL Server Data Source
Table with 250M rows
Aggregated table: Sales Agg
In Memory Storage of Power BI
Aggregated table: Sales and Promotion Agg
SalesAmount by Gender
$15M
$10M
$5M
$0M
F
M
Axis
Gender
Legend
Add data fields here
Value
SalesAmount
Tooltips
Add data fields here

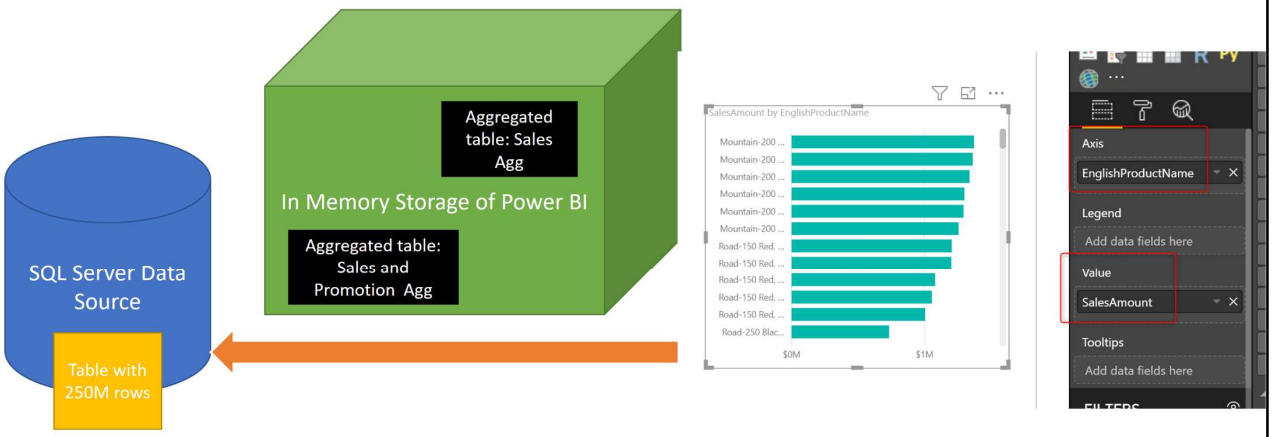
148

Query hits the second aggregated table in the memory



149

Query hits the DirectQuery table in the data source



150

Automatic Aggregations

Scheduled refresh and performance optimization

To improve the performance of exploring reports, enable scheduled refresh and automatic aggregations and estimate how caching can improve query response times.

Automatic aggregations training

To speed up exploring reports, Power BI can generate aggregations tables to cache some of the data for queries-your reports will run faster, and visuals with cached data will load more quickly. Learn more

On

Query coverage

Adjust the percentage of queries that will use aggregated caches.

95%

Increasing the percentage of queries that use aggregations increases refresh time and data latency. More aggregations generate more queries on the source system. More queries increase the probability of query timeouts, system overload and costs.

151

Incremental Refresh

152

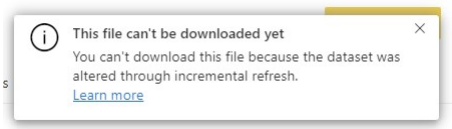
What is Incremental Refresh?

- Full-load; One partition
- Partitioning
  - Historical data (load once)
  - Recent data (load regularly)
- Hybrid tables
  - Historical data (load once)
  - Recent data (load regularly)
  - Most recent period (DirectQuery Connection)

153

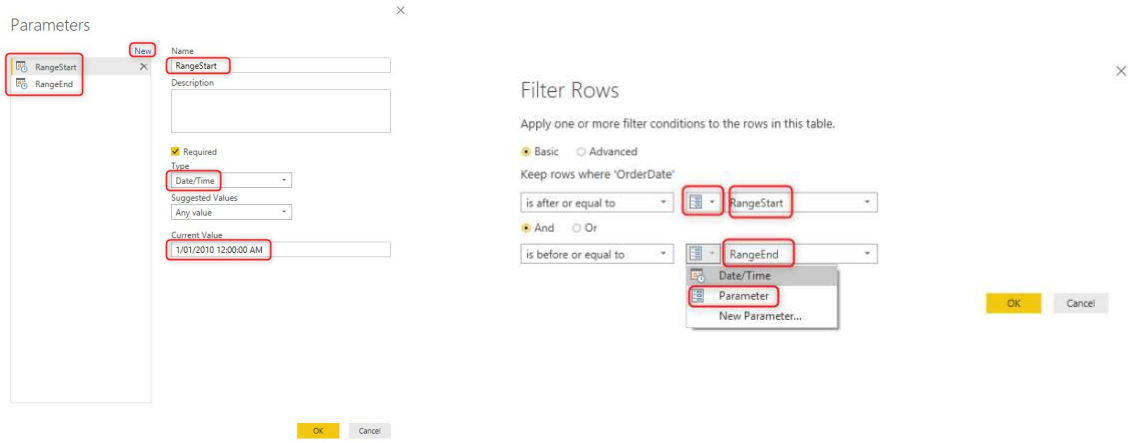
Set up Incremental Refresh

- Table with Date Field(s)
- A data source that supports query folding
- Licensing Requirement



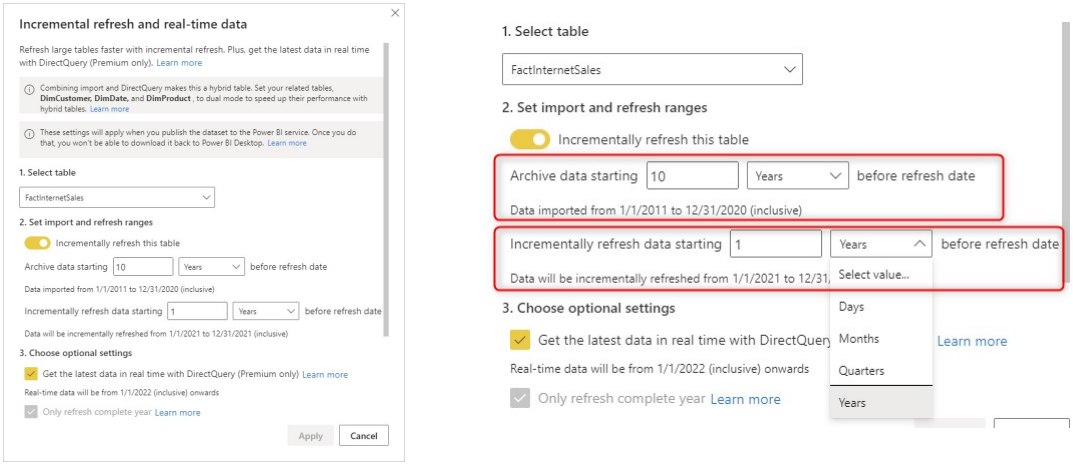
154

Power Query Parameters



155

Incremental Refresh Setting



156

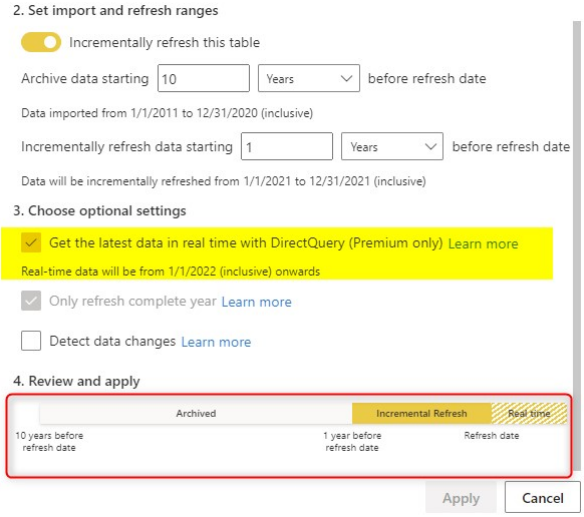
Hybrid Tables

Granularity	Name	Row Count
Year	2011	295,489,717
Year	2012	297,678,498
Year	2013	295,575,442
Year	2014	292,477,875
Year	2015	297,780,469
Year	2016	294,060,081
Year	2017	300,419,682
Year	2018	296,541,108
Year	2019	292,787,420
Year	2020	299,273,979
Quarter	2021Q1	74,135,277
Month	2021Q104	24,939,498
Day	2021Q10501	820,805
Day	2021Q10502	826,885
Day	2021Q10503	821,043
Day-DirectQuery	2021Q10504-DQ	271,110
Total		**3,063,898,887**

Archived: **Import**

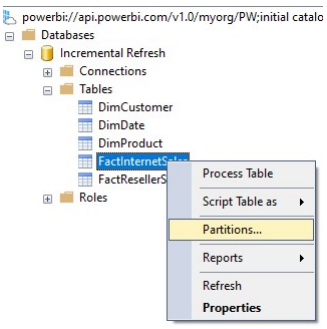
Incremental refresh: **Import**

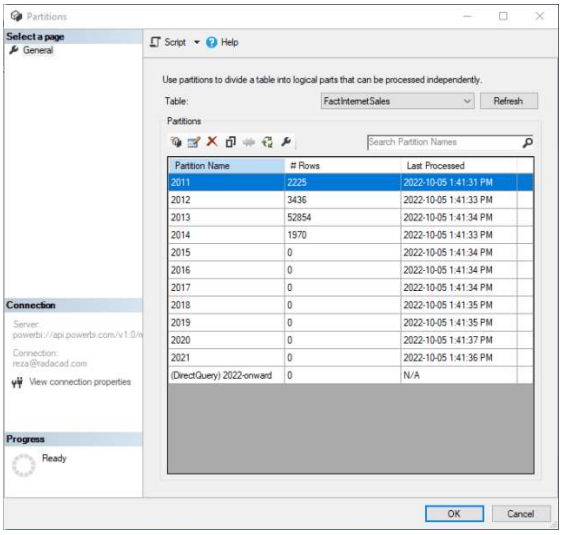
Real time: **DirectQuery**



157

Partitions



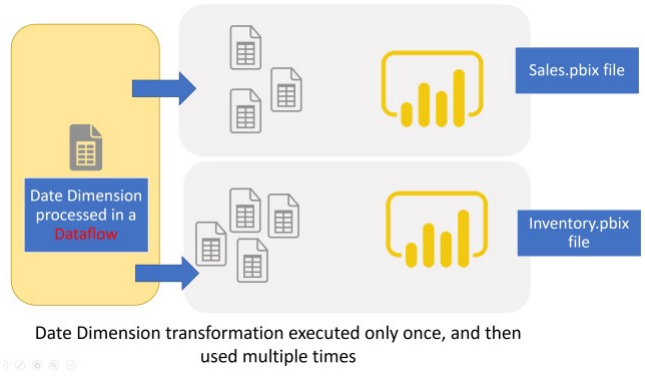


158

Development Best Practices

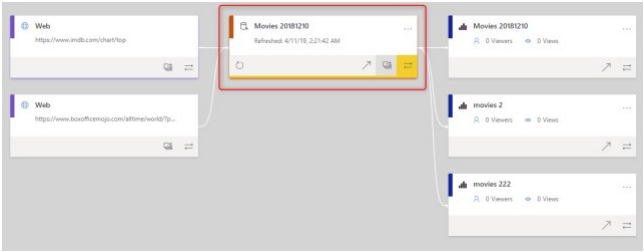
159

Re-use tables generated in Power Query



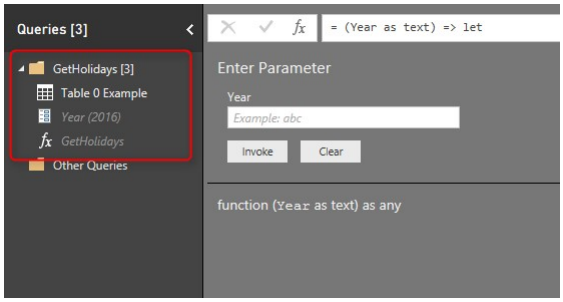
160

Re-use DAX calculations



161

Power Query Functions for re-usable data transformation

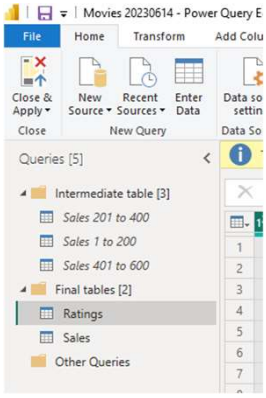


162

Parametrize the Data Transformation Process using Power Query Parameters

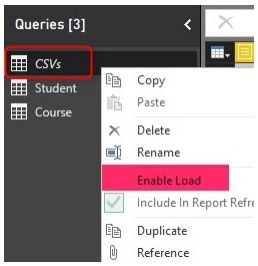
163

Categorize Power Query using Power Query Groups (or Folders)



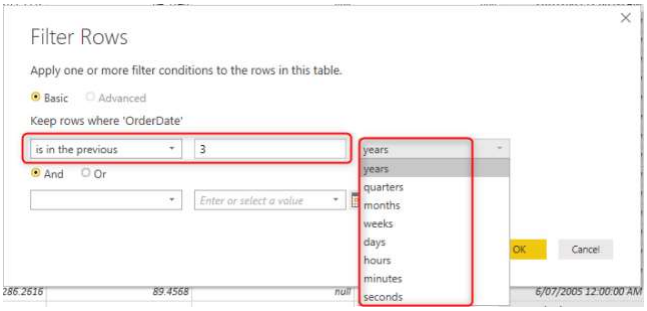
164

Disable the load of temp tables in the Power Query



165

Just load what you need for reporting, Filter the data

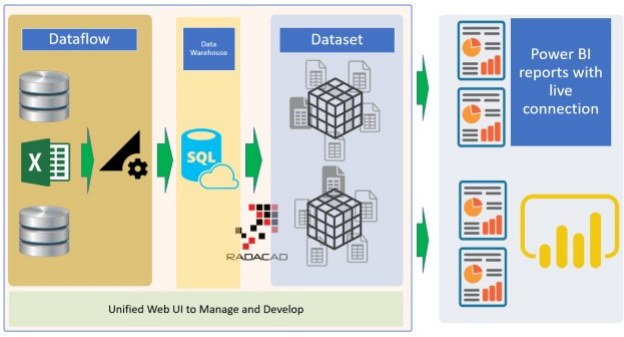


166

Use the "Reference" and "Duplicate" in their rightful places

167

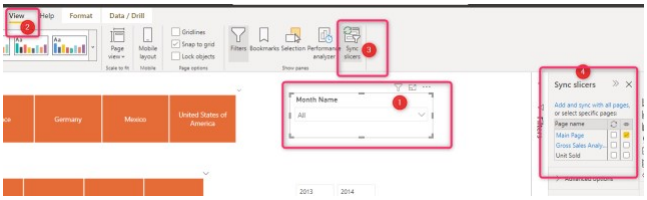
Multi-Layer Architecture Everywhere



Power BI Solution Architecture using Datamart

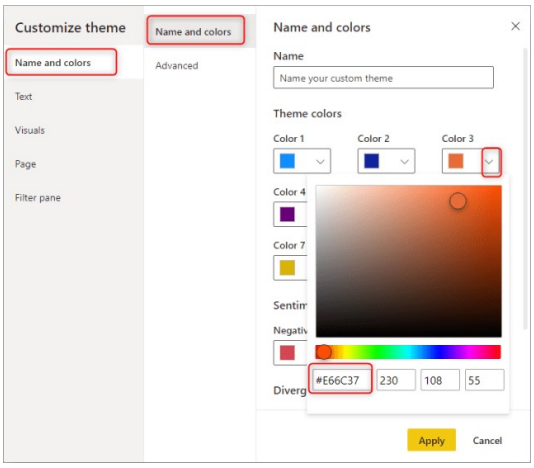
168

Sync Slicers



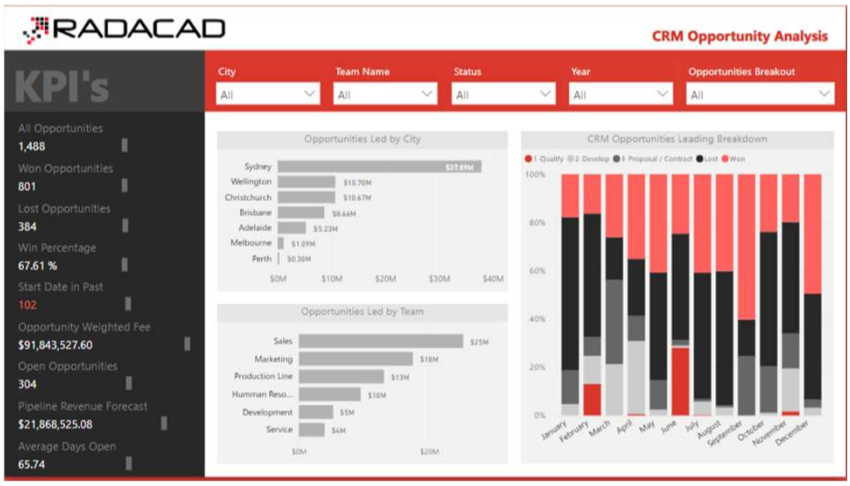
169

Use a Theme file



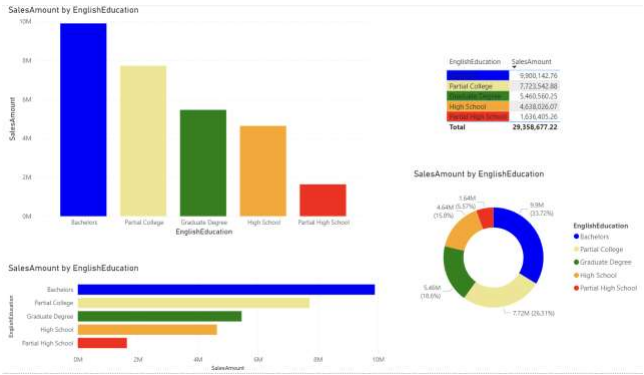
170

Background image for report pages



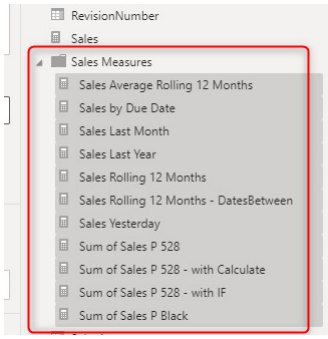
171

Conditional formatting using DAX, parameters, and tables



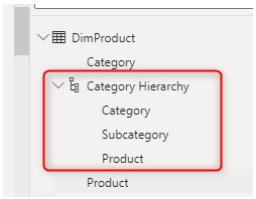
172

Measure table



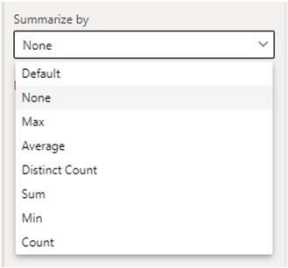
173

Create and Use Hierarchies



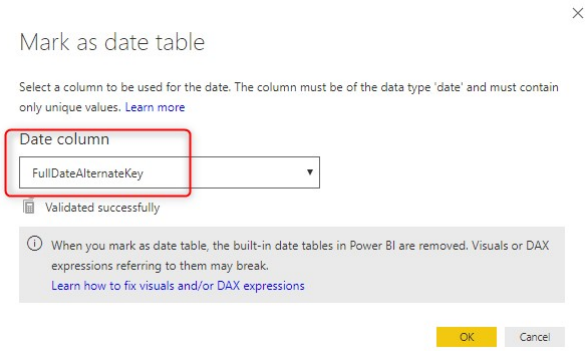
174

Set Auto Summarization at the field level



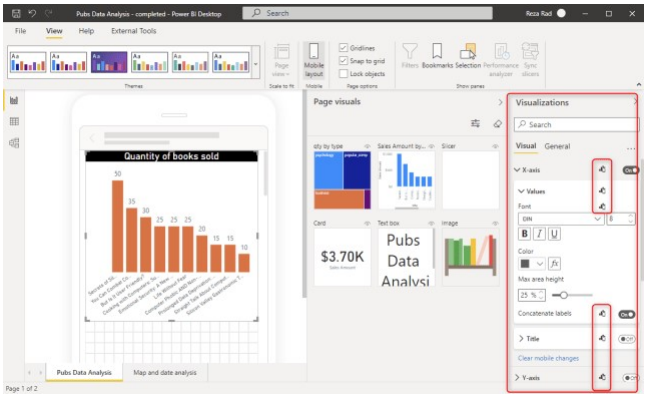
175

Consider using a custom Date Table



176

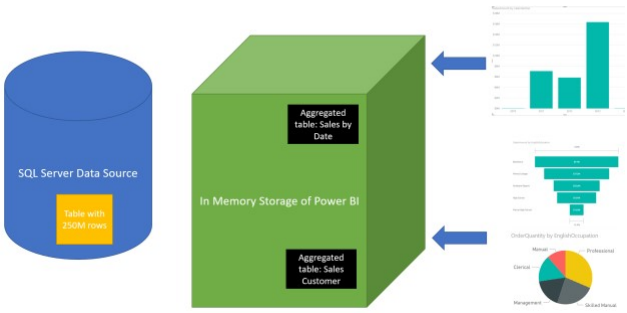
Design Mobile reports



177

Use Aggregations for big tables

Queries will be answered by Aggregated tables if exists



178

Use Incremental Refresh and Hybrid tables Where Possible

Granularity	Name	Row Count
Year	2011	295,489,717
Year	2012	297,678,498
Year	2013	295,575,442
Year	2014	292,477,875
Year	2015	297,780,469
Year	2016	294,060,081
Year	2017	300,419,682
Year	2018	296,541,108
Year	2019	292,787,420
Year	2020	299,273,979
Quarter	2021Q1	74,135,277
Month	2021Q104	24,939,498
Day	2021Q10501	820,805
Day	2021Q10502	826,885
Day	2021Q10503	821,043
Day-DirectQuery	2021Q10504-DQ	271,110
Total		**3,063,898,887**

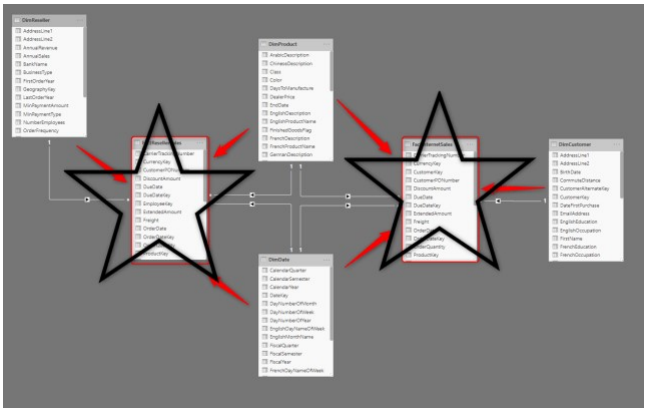
Archived: **Import**

Incremental refresh: **Import**

Real time: **DirectQuery**

179

Design Star Schema Models

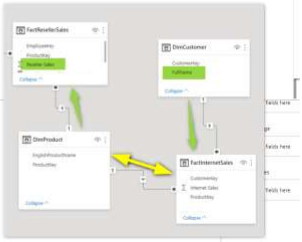


180

Avoid both-directional relationship

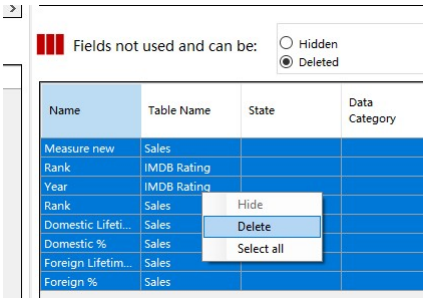
```
Reseller Sales of the products that this customer purchased =
CALCULATE(
    SUM(FactResellerSales[Reseller Sales]),
    CROSSFILTER(
        DimProduct[ProductKey],
        FactInternetSales[ProductKey],
        Both)
)
```

FullName	Internet Sales	Reseller Sales	Reseller Sales of the products that this customer purchased
Aaron Adams	$117.96	$80,450,596.98	$39,328.16
Aaron Alexander	$69.99	$80,450,596.98	$115,867.17
Aaron Allen	$3,199.99	$80,450,596.98	$1,052,610.05
Aaron Baker	$1,750.98	$80,450,596.98	$750,019.68
Aaron Bryant	$133.96	$80,450,596.98	$61,772.62
Aaron Butler	$14.98	$80,450,596.98	$7,476.60
Aaron Campbell	$1,155.48	$80,450,596.98	$426,960.86
Aaron Carter	$39.98	$80,450,596.98	$43,990.46
Aaron Chen	$39.98	$80,450,596.98	$39,328.16
Aaron Coleman	$61.96	$80,450,596.98	$43,990.46
Total	$29,358,677.22	$80,450,596.98	$80,450,596.98



181

Model clean up



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Deployment & Collaboration

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Agenda: Deployment

- Power BI Service
- Power BI report server
- Gateway and configurations
- Licensing guide (and PPU)
- Tenant settings
- PowerShell Cmdlets for Power BI
- REST API for deployment and administrations
- Audit Log, Admin reports and metrics
- Workspace structure and architecture
- Workspace roles
- Deployment pipelines
- XMLA endpoint

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Agenda: Sharing

- Content certification and governance
- Individual sharing
- Workspace sharing
- App
- Embed code and publish to web and embed in sharepoint
- Teams integration and Sharepoint online
- Power BI Embedded
- Compare sharing methods
- RLS, OLS, CLS

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Power BI Service

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Power BI Service

- Cloud-based hosting for Power BI objects
- Dataflow, Datamart, Dataset
- Power BI report, Paginated report
- Metrics
- Dashboard
- Workspace and App
- Administration and configurations
- Service connectors / Template apps

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Power BI Report Server

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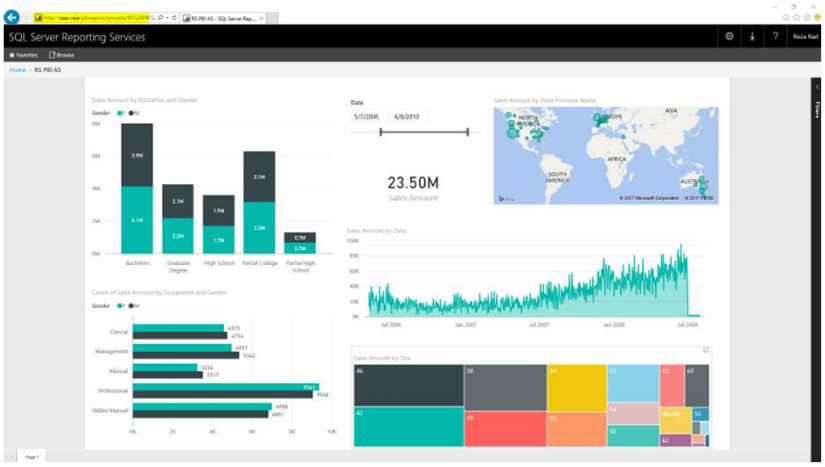
Power BI Report Server



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What's included?

- SQL Server Enterprise Edition OR Power BI Premium Licensing
- Web portal
- Power BI reports
- Paginated reports
- Power BI Desktop Report Server

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Not included

- Analyze in Excel
- Composite model
- Dashboard
- Apps
- Shared dataset
- Q&A
- Cross report drill through
- Preview features
- Metrics
- Dataflow
- Datamart

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Download

- https://powerbi.microsoft.com/en-us/report-server/

Microsoft Power BI Report Server- September 2022

Important! Selecting a language below will dynamically change the complete page content to that language.

Select Language: English Download

Power BI Report Server, available as part of Power BI Premium, enables on-premises web and mobile viewing of Power BI reports, plus the enterprise reporting capabilities of SQL Server Reporting Services.

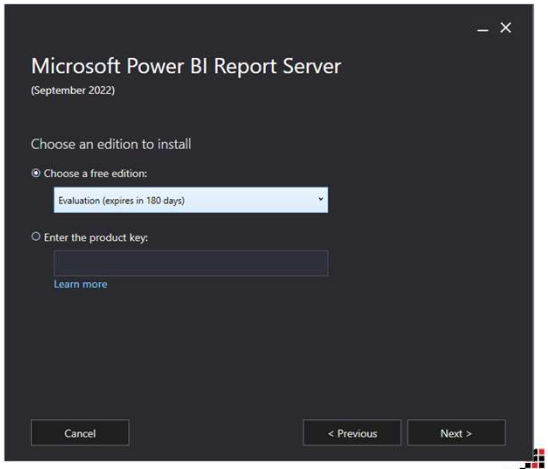
Details

Note: There are multiple files available for this download. Once you click on the "Download" button, you will be prompted to select the files you need.

Version:	Date Published:
15.0.1110.120	10/5/2022
File Name:	**File Size:**
PBIDesktopRS.msi	305.2 MB
PBIDesktopRS_x64.msi	344.4 MB
PowerBIReportServer.exe	401.9 MB

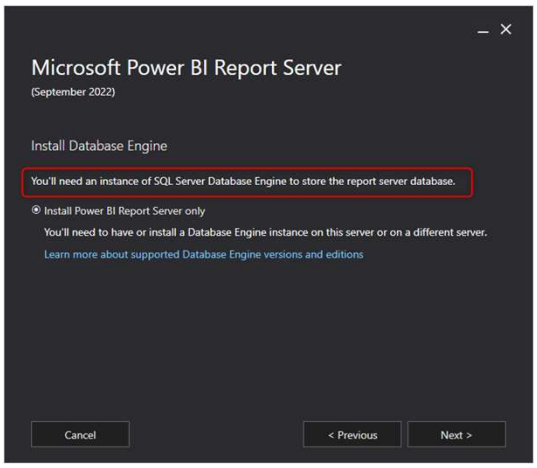
192

Installing



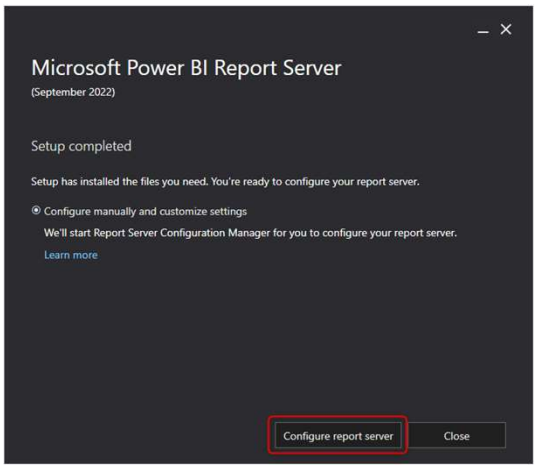
193

You will need SQL Server database engine



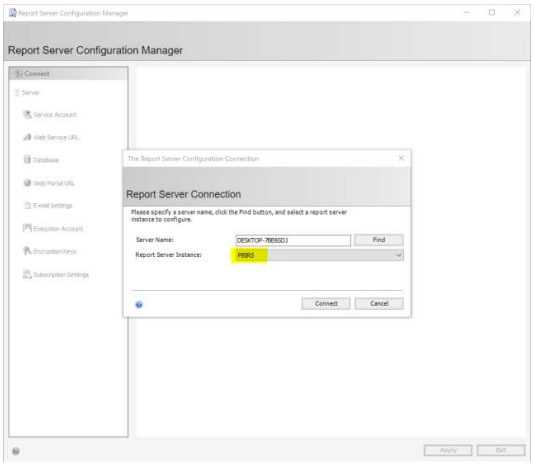
194

Configure Report Server



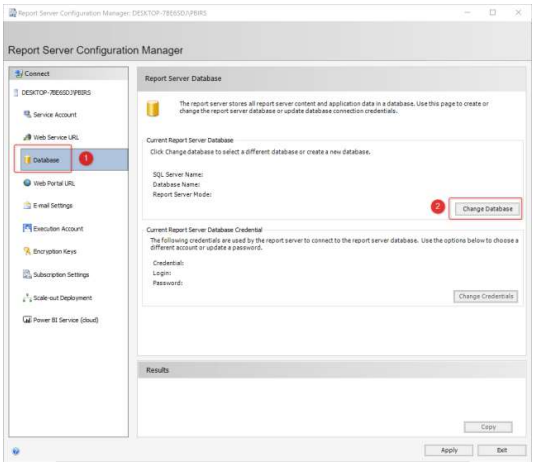
195

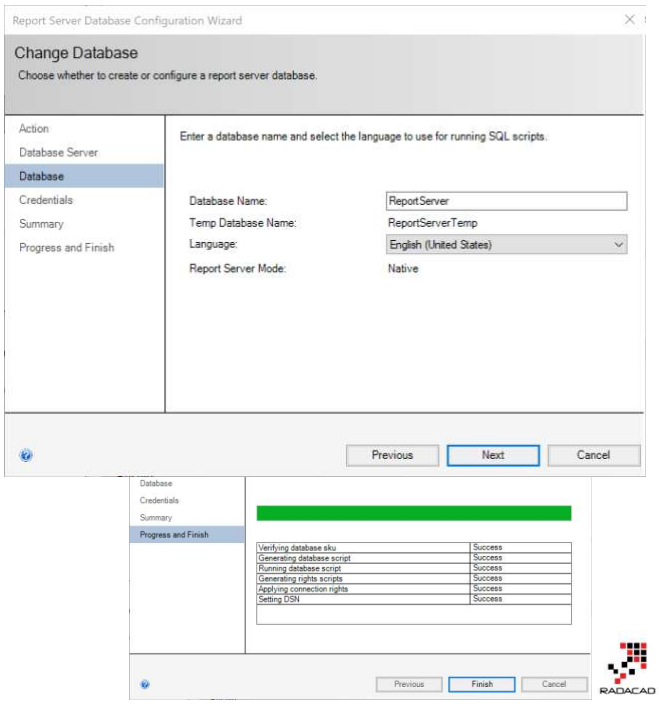
Report Server Configuration Manager



196

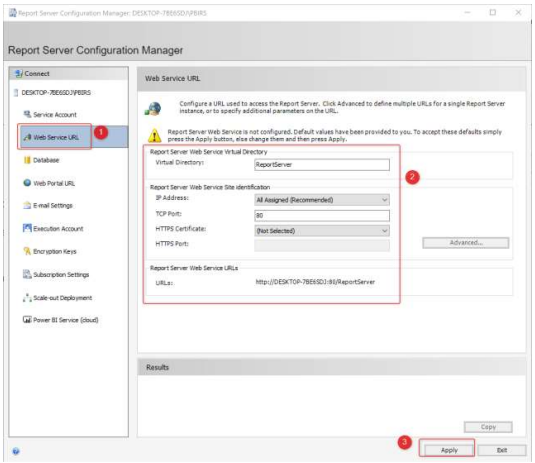
Database setup





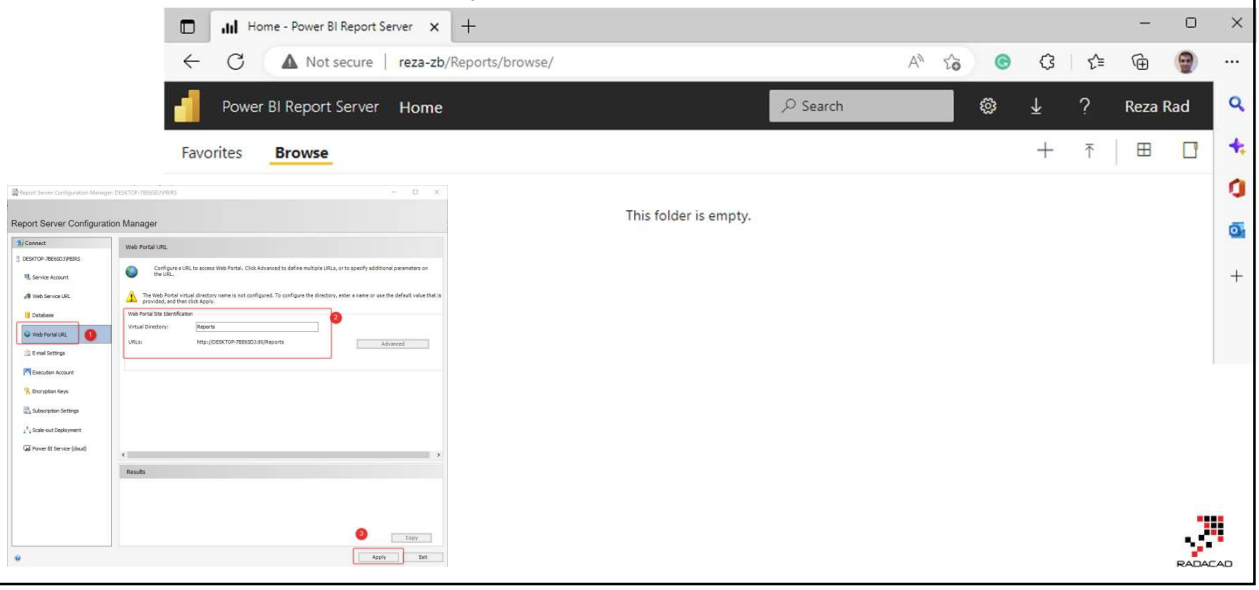
197

Web Service set up



198

Web Portal Set up



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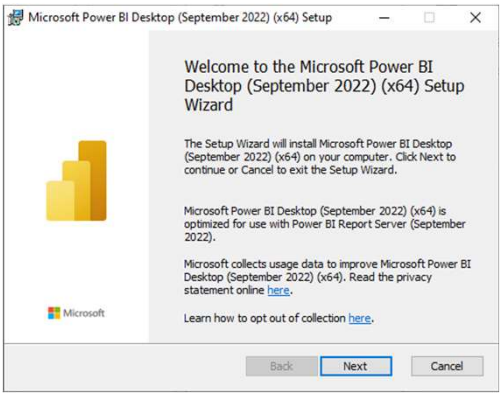
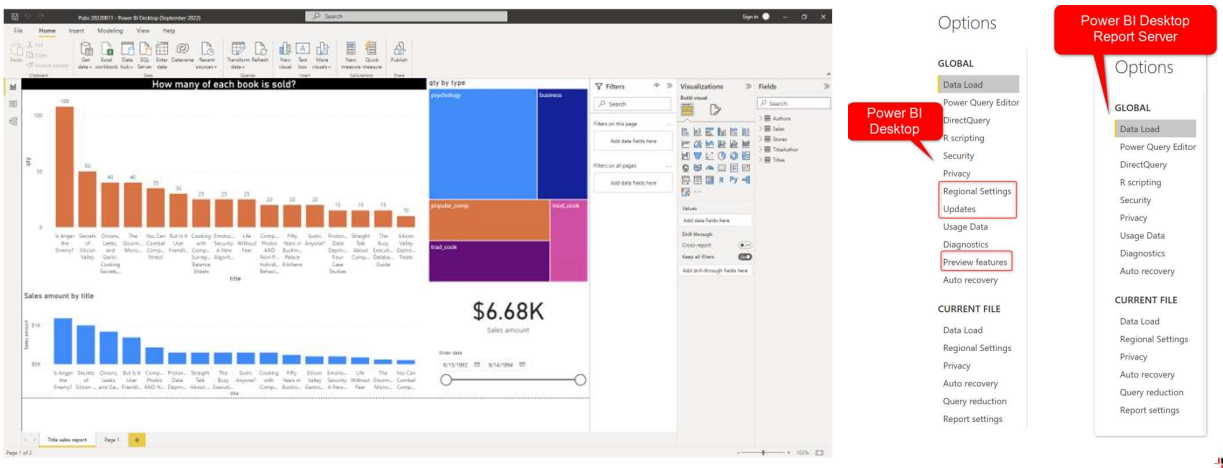
Power BI Desktop > Report Server Edition



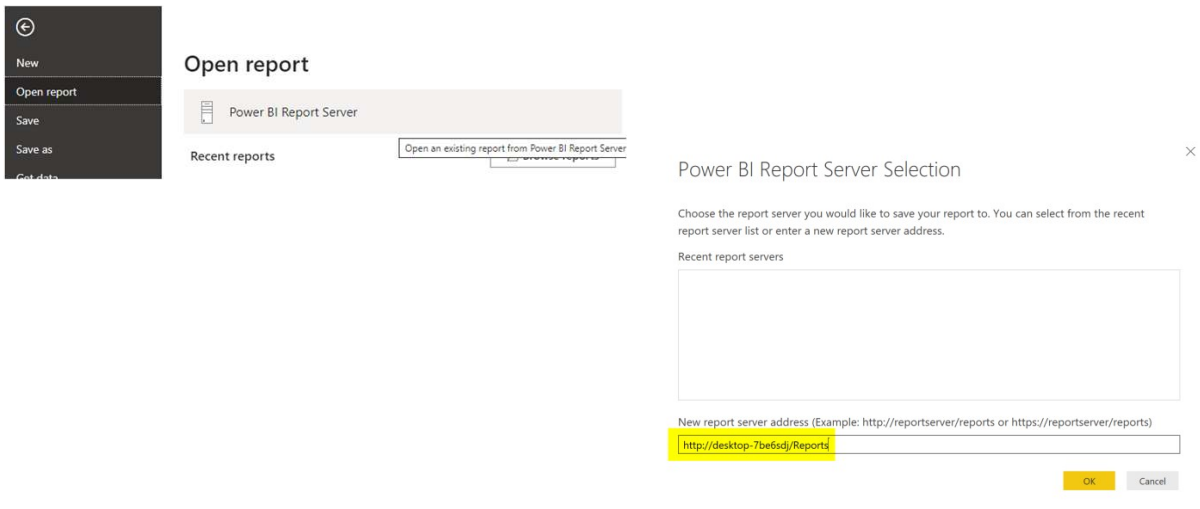
200

Like Power BI Desktop with a few differences



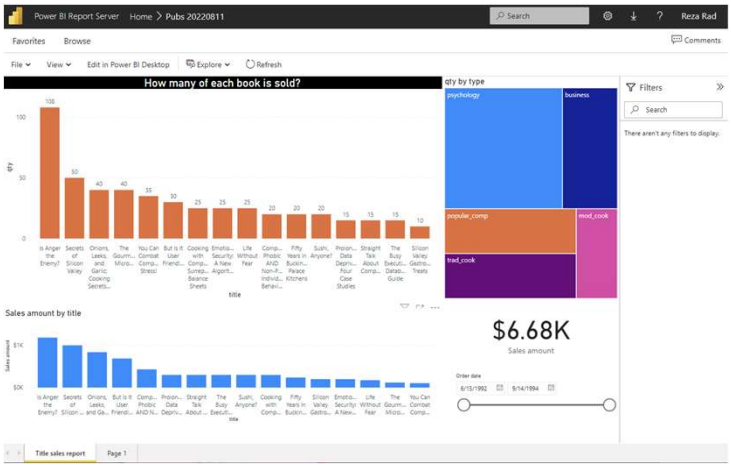
201

Publish to Report Server



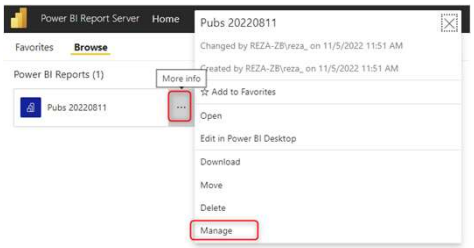
202

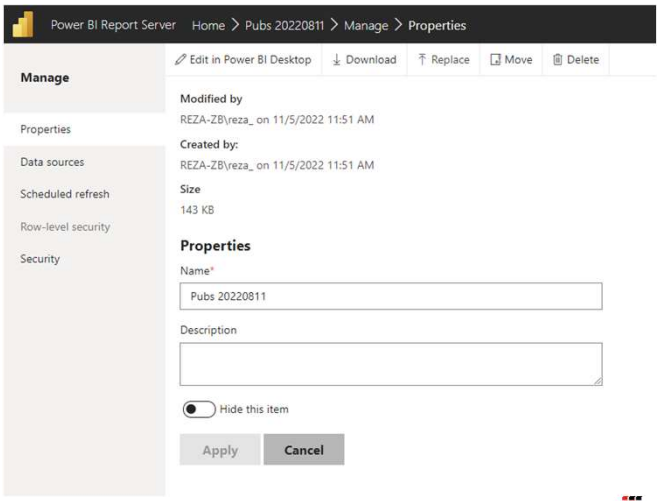
Report in the Report Server



203

Dataset Settings

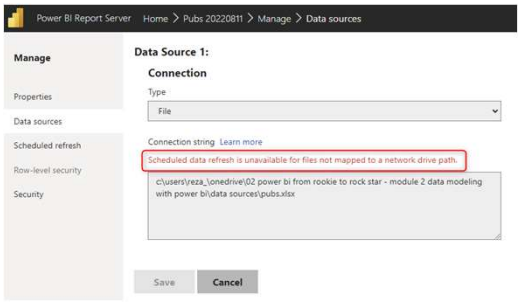


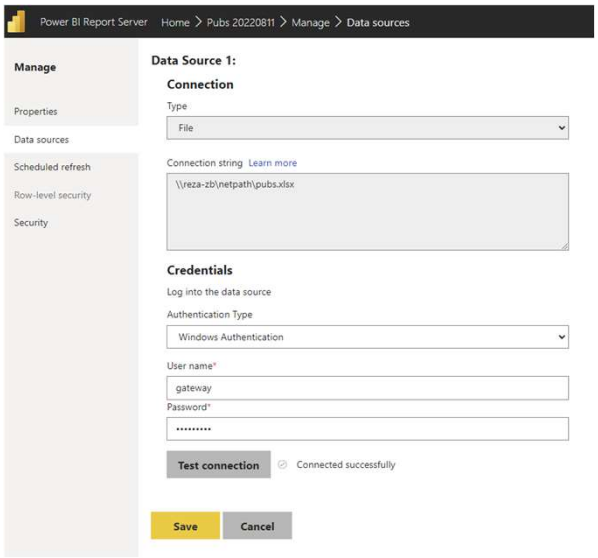


204

Schedule Refresh

- Shared path for files and folders



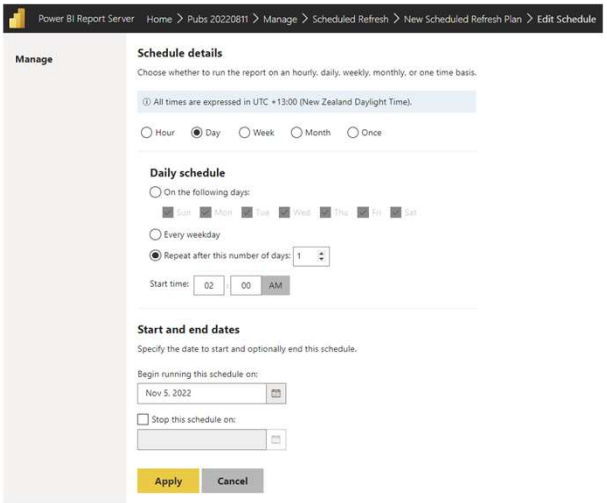


RADACAD

205

Schedule Refresh

- SQL Server Agent



RADACAD

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Pros and Cons of Report Server

- The only fully on-prem solution
- No Gateway needed
- All types of connection (except Composite) are supported
- Licensing
- Power BI Service Features Not available

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Gateway

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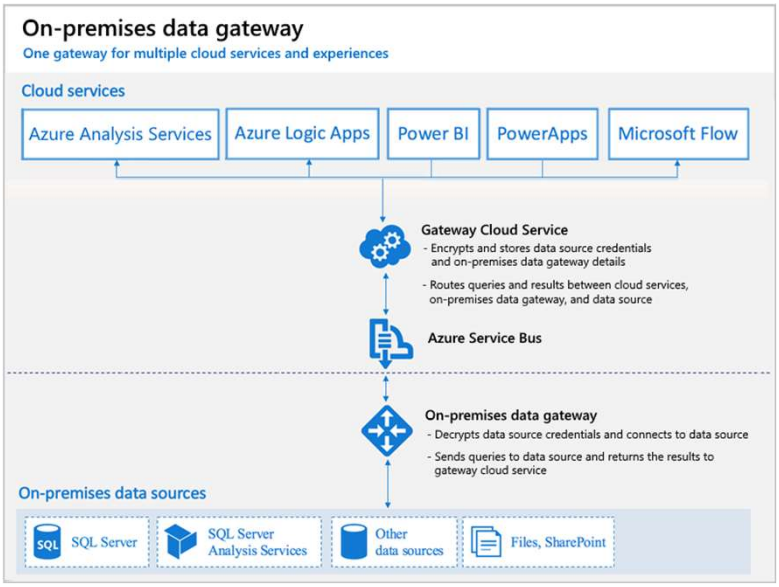
What is the Gateway?



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Two Modes of Gateway

	Personal Mode	Enterprise/Standard/On-Premises Mode (Recommended)
Target Persona	Business Analyst who wants to set up and use gateway to run his/her reports	BI Admins to set up the gateway for their companies Multiple BI developers to use the gateway for their reports
Usage	Analyst	BI Admin Developer
Connection Type	Import Data or Scheduled Refresh	Import Data or Schedule Refresh Live Connection DirectQuery
Management	Per user data source management	Central data source management
Monitoring/Control	No monitoring/Control	Central Monitoring and Control
Services Supported	Power BI only	Power BI PowerApps Microsoft Flow Azure Logic Apps Azure Analysis Services

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Architecture: Refresh with Gateways

1.Gateway is installed & configured. During configuration, a corresponding service bus instance is also configured.

2.Credentials entered for the data source in Power BI are encrypted then stored in the cloud. Only the gateway can decrypt the credentials. Personal Gateway windows credentials is stored in the Gateway only.

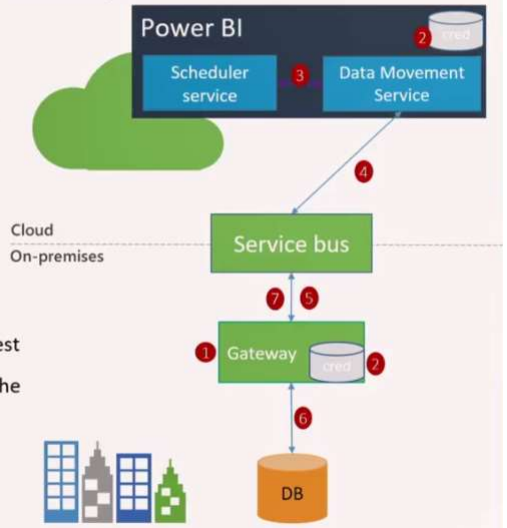
3.Power BI kicks off a refresh

4. Data Movement Service analyzes the query and pushes to appropriate service bus instance

5.Gateway polls bus for pending requests. It takes the pending request

6.Gateway gets the query, decrypts the credentials, sends query to the data source for execution

7.After execution, gateway securely pushes the data to Power BI



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Online Data?

- You Don't need Gateway for online data.
- Such as CRM online, MailChimp, Azure SQL DB…

- However, for SQL Server hosted in an Azure VM, you need a gateway

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Recommended System for Gateway

Minimum Requirements:

- .NET Framework 4.7.2 (Gateway release December 2020 and earlier)
- .NET Framework 4.8 (Gateway release February 2021 and later)
- A 64-bit version of Windows 8 or a 64-bit version of Windows Server 2012 R2 with current TLS 1.2 and cipher suites
- 4-GB disk space for performance monitoring logs (in the default configuration)

Recommended:

- An 8-core CPU
- 8 GB of memory
- A 64-bit version of Windows Server 2012 R2 or later
- Solid-state drive (SSD) storage for spooling.

Not Recommended on Domain Controller*

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Ports

- The gateway creates an outbound connection to Azure Service Bus. It communicates on outbound ports: TCP 443 (default), 5671, 5672, 9350 thru 9354. The gateway does not require inbound ports

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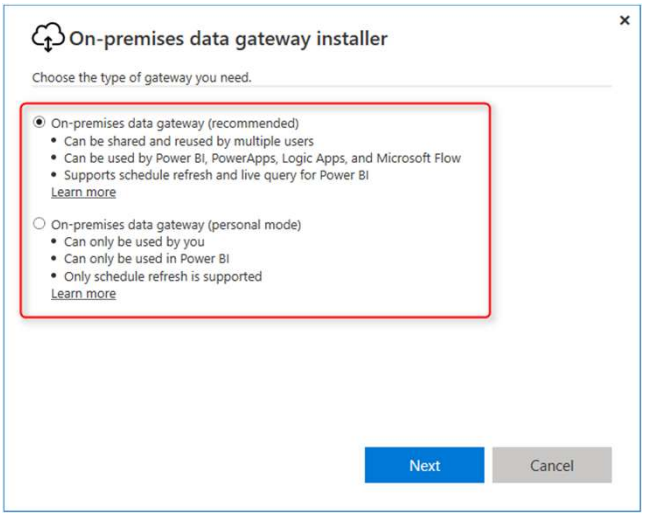
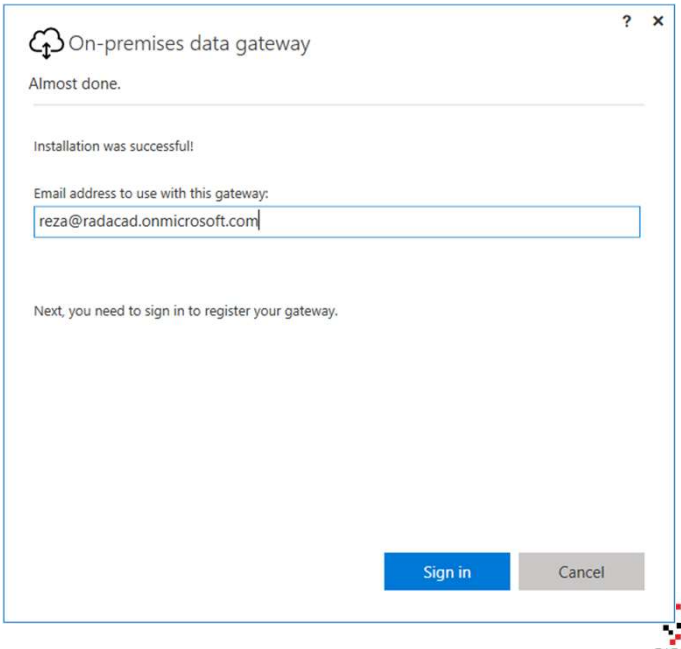
Installation

- One Gateway is enough (depends)
- Can be on a different server in that Domain AD



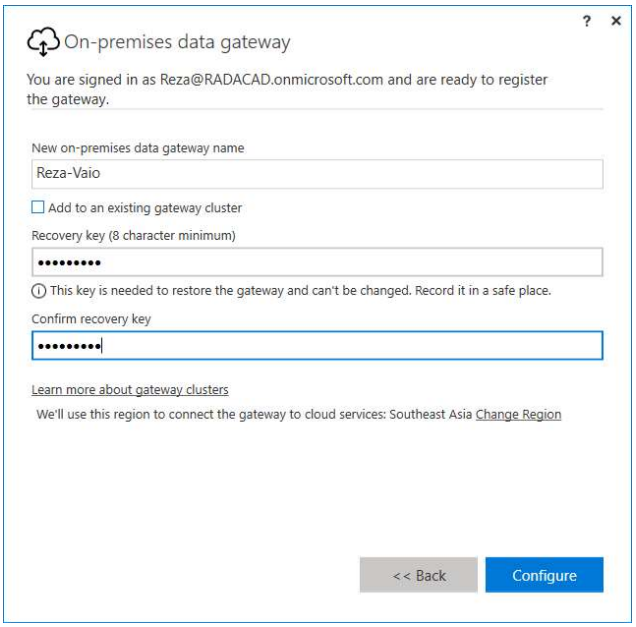
215

Connected to Power BI Account



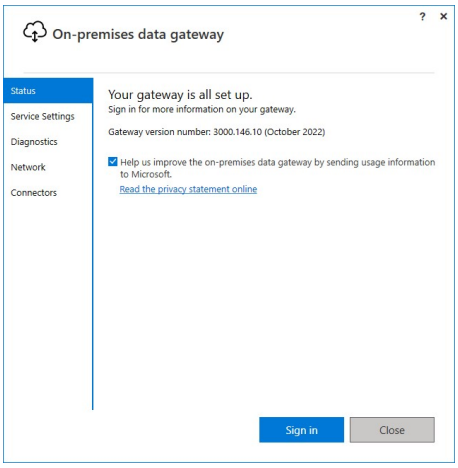
216

Recovery Key



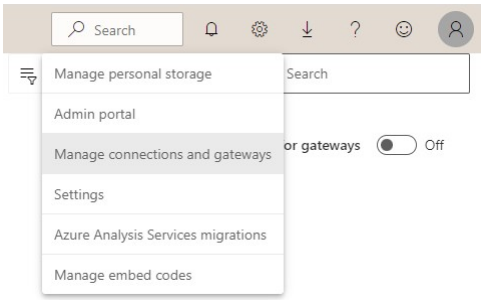
217

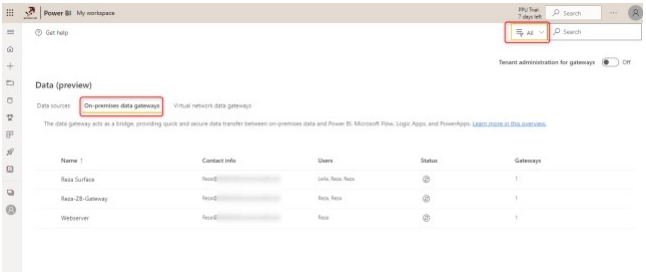
Successful Installation



218

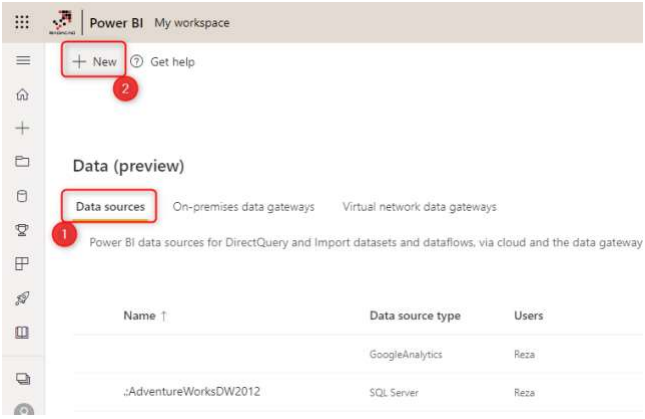
Gateway Setup in the Service





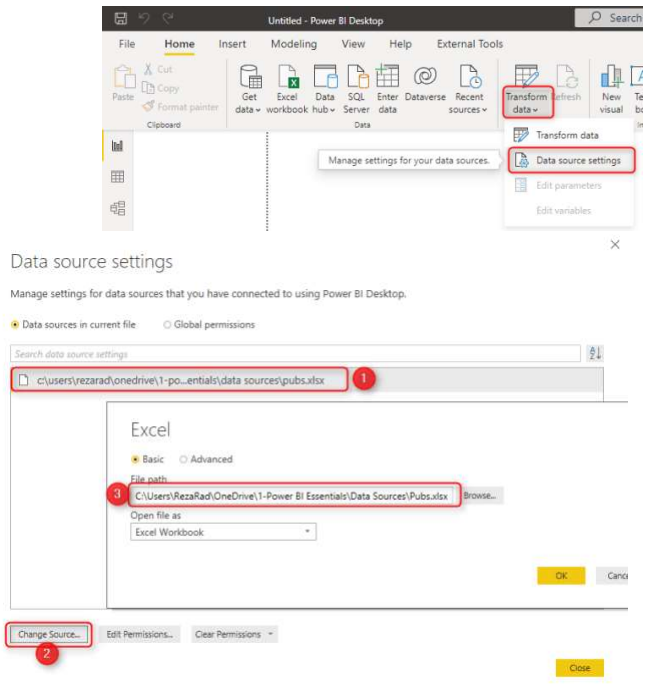
219

Adding Data Source



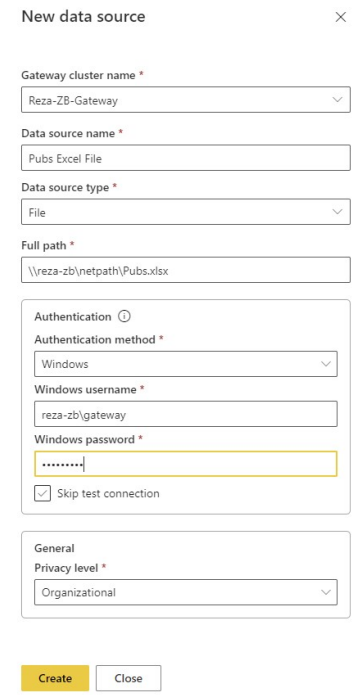
220

Data Source Settings



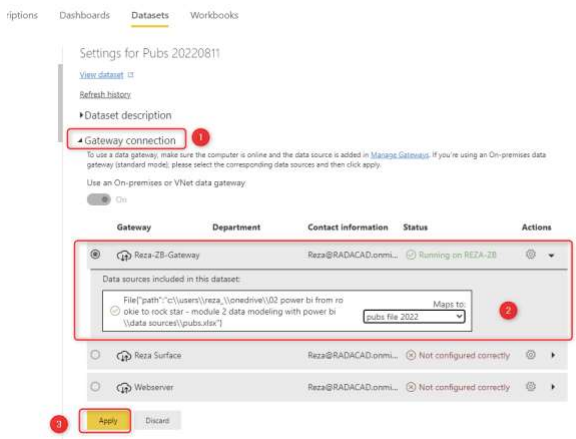
221

Data Source added Successfully



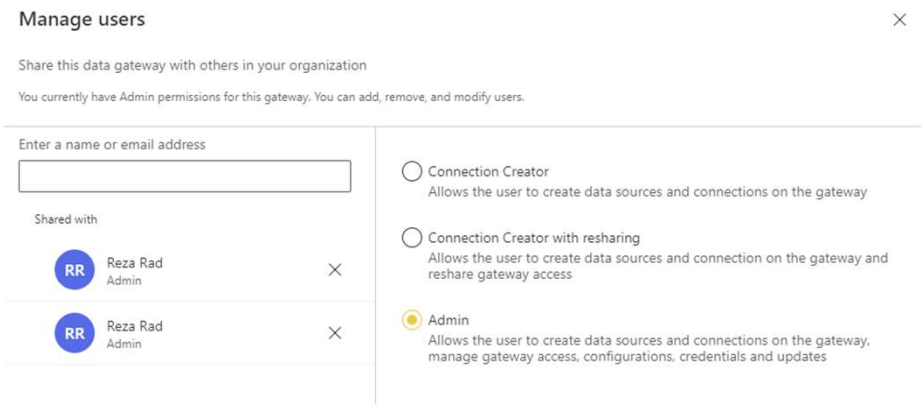
222

Binding Gateway to the dataset



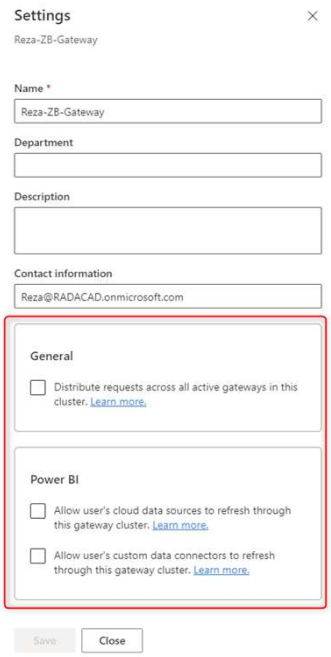
223

Gateway Users and access control



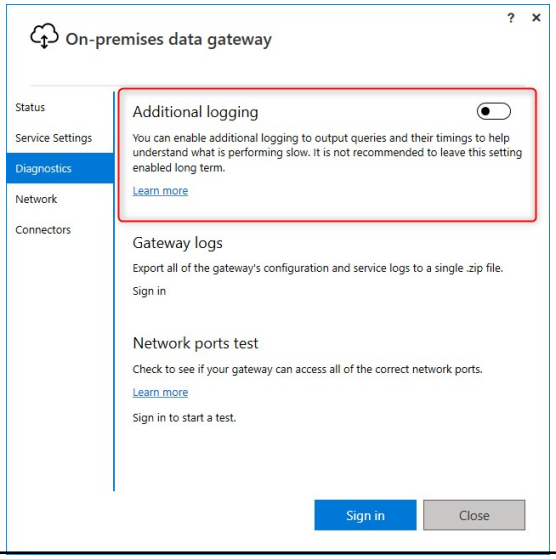
224

Gateway additional settings



225

Troubleshooting



226

How to Restart

- The gateway runs as a windows service. You can start and stop it like any windows service. There are multiple ways to do this. Here is how you can do it from the command prompt.
- On the machine where the gateway is running, launch an admin command prompt. Use the following command to stop the service.

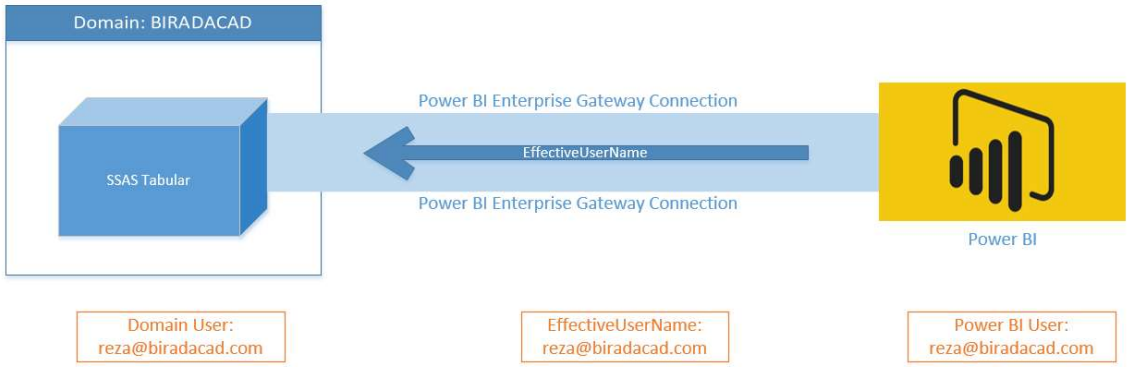
net stop PBIEgwService

- Use the following command to start the service.

net start PBIEgwService

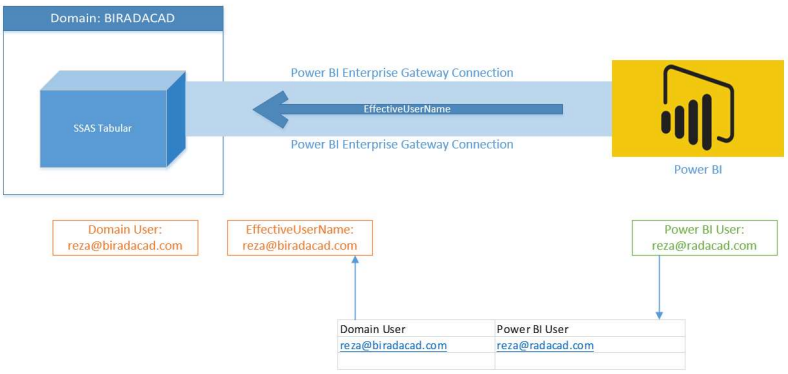
227

Connection from the Service



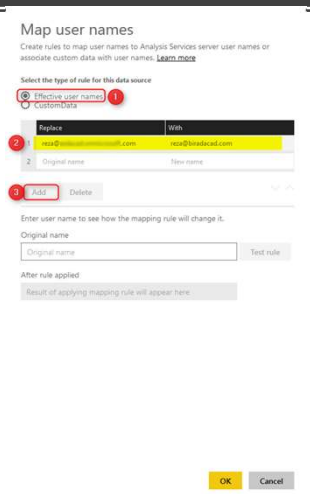
228

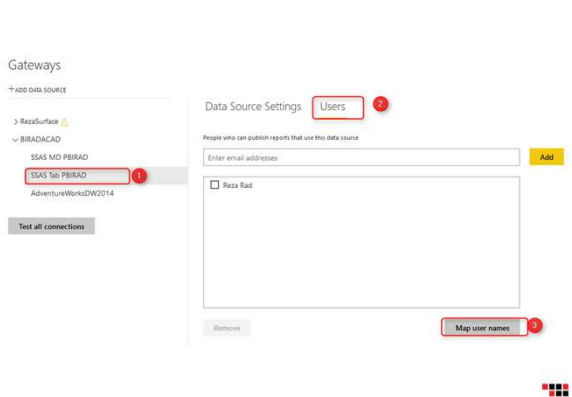
When Local AD and Office365 are Different



229

UPN Mapping under Gateway Config





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Licensing

231

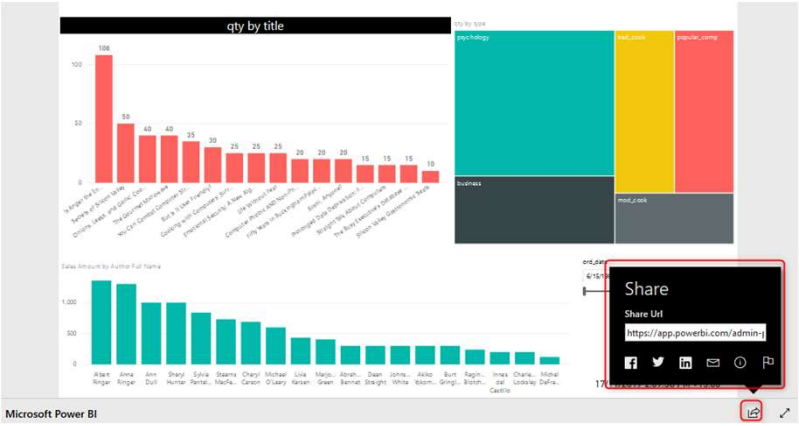
Per User / Capacity based

Per User
- Power BI Free
- Power BI Pro
- Premium Per User (PPU)

Capacity Based
- Premium
- Embedded A/EM SKUs

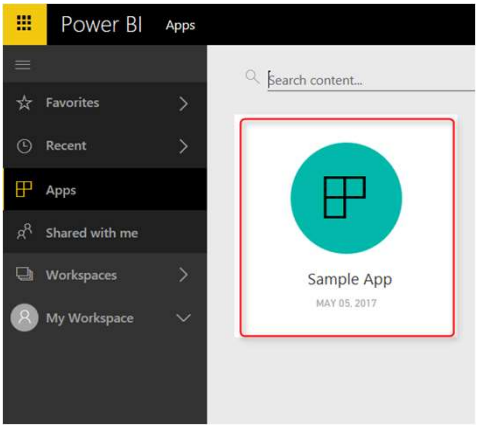
232

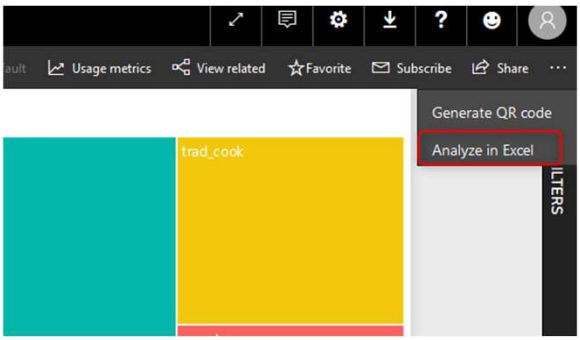
Power BI Free



233

Power BI Pro





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Power BI Premium

- For large user base
- When extra compute power is needed
  - Huge models: up to 400GB
  - Computed Entity…
  - Dedicated resources
- Extra functionalities
  - Geo-replica
  - AI/Dataflow advanced
  - More refreshes
  - Datamarts
  - …

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Power BI Premium

Capacity		Dataset				Dataflow	Export API
Capacity SKUs	V-cores	Max memory (GB)[1, 2, 3]	DirectQuery/Live connection (per second)[1, 2]	Max memory per query (GB)[1, 2]	Model refresh parallelism[2]	Dataflow parallel tasks[5]	Max concurrent pages[6]
EM1/A1	1	3	3.75	1	5	4	20
EM2/A2	2	5	7.5	2	10	8	25
EM3/A3	4	10	15	2	20	16	35
P1/A4	8	25	30	6	40	32	55
P2/A5	16	50	60	6	80	64	95
P3/A6	32	100	120	10	160	64	175
P4/A7[4]	64	200	240	10	320	64	200
P5/A8[4]	128	400	480	10	640	64	200

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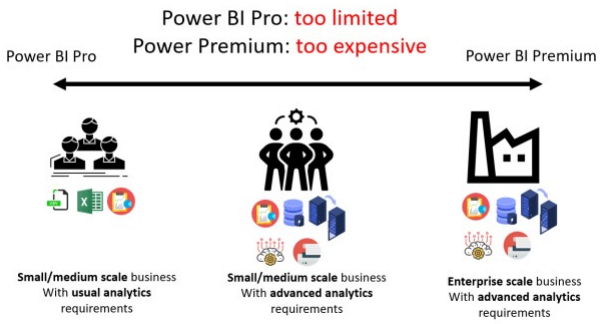
PPU



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PPU Vs. Premium Capacity

Feature description	Per User	Per Capacity
Model size limit	100 GB	Up to 400 GB
Refresh rate	48/day	48/day
Paginated reports	✓	✓
AI capabilities (AutoML, Impact Analysis, Cognitive Services)	✓	✓
Advanced dataflows features, such as DirectQuery	✓	✓
Usage-based aggregate optimization	✓	✓
Deployment Pipelines	✓	✓
XMLA endpoint connectivity	✓	✓
Enhanced automatic page refresh	✓	✓
Incremental refresh	✓	✓
Multi-Geo support	X	✓
Unlimited distribution	X	✓
Power BI reports on-premises	X	✓
Bring Your Own Key (BYOK)	✓ *	✓

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Power BI Embedded

- Kind of a Hybrid option
- Dedicated capacity, but can be low cost

Region: Central US | Currency: United States – Dollar ($) USD | Display pricing by: Hour

The total cost of Power BI Embedded depends on the node type chosen and the number of nodes deployed. Node types differ based on number of V-cores and RAM as outlined in the table below:

Node Type	Virtual Cores	Memory	Frontend / Backend Cores	Price
A1	1	3 GB RAM	0.5 / 0.5	$1.0081/hour
A2	2	5 GB RAM	1 / 1	$2.0081/hour
A3	4	10 GB RAM	2 / 2	$4.0242/hour
A4	8	25 GB RAM	4 / 4	$8.0565/hour
A5	16	50 GB RAM	8 / 8	$16.121/hour
A6	32	100 GB RAM	16 / 16	$32.2506/hour
A7	64	200 GB RAM	32 / 32	N/A
A8	128	400 GB RAM	64 / 64	N/A

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A VS. EM SKUs

Scenario	Azure	Office
	(A SKU)	(P and EM SKUs)
Embed for your customers (app owns data)	✓	✓
Embed for your organization (user owns data)	✕	✓
Microsoft 365 apps (formerly known as Office 365 apps) • Embed in Teams • Embed in SharePoint	✕	✓
Secure URL embedding (embed from Power BI service)	✕	✓

Payment and usage	Power BI Embedded	Power BI Premium	Power BI Premium
Offer	Azure	Office	Office
SKU	A	EM	P
Billing	Hourly	Monthly	Monthly
Commitment	None	Yearly	Monthly or yearly
Usage	Azure resources can be: • Scaled up or down • Paused and resumed	Embed in apps, and in Microsoft applications	Embed in apps, and in Power BI service

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Power BI Report Server

- Premium
- SQL Server Enterprise Edition + Software Assurance

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Fabric Licensing

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SKUs and Pricing

SKU*	Capacity Units (CU)	Power BI SKU	Power BI v-cores	Hourly $	Monthly $
F2	2	-	0.25	$0.36	$262.80
F4	4	-	0.5	$0.72	$525.60
F8	8	EM/A1	1	$1.44	$1,051.20
F16	16	EM2/A2	2	$2.88	$2,102.40
F32	32	EM3/A3	4	$5.76	$4,204.80
F64	64	P1/A4	8	$11.52	$8,409.60
F128	128	P2/A5	16	$23.04	$16,819.20
F256	256	P3/A6	32	$46.08	$33,638.40
F512	512	P4/A7	64	$92.16	$67,276.80
F1024	1024	P5/A8	128	$184.32	$134,553.60
F2048	2048	-	256	$368.64	$269,107.20

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Storage

- ADLS: Azure Data Lake Storage
- $0.023 per GB (US West 2) monthly
- Cross-region transfer may have extra charges

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F2 is not for Power BI Sharing

- F64 is the minimum SKU needed for Power BI sharing with free accounts.
- Lower than F64, you will need Pro or PPU accounts for sharing Power BI content

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Low F's + Power BI Pro: Perfect for SMB

- Low F SKU (F2 for example)
- Power BI Pro

- 50 PPU accounts: $1,000 monthly
- 50 Pro + F2: Less than $800 monthly

SKU*	Capacity Units (CU)	Power BI SKU	Power BI v-cores	Hourly $	Monthly $
F2	2	-	0.25	$0.36	$262.80
F4	4	-	0.5	$0.72	$525.60
F8	8	EM/A1	1	$1.44	$1,051.20
F16	16	EM2/A2	2	$2.88	$2,102.40
F32	32	EM3/A3	4	$5.76	$4,204.80
F64	64	P1/A4	8	$11.52	$8,409.60
F128	128	P2/A5	16	$23.04	$16,819.20
F256	256	P3/A6	32	$46.08	$33,638.40
F512	512	P4/A7	64	$92.16	$67,276.80
F1024	1024	P5/A8	128	$184.32	$134,553.60
F2048	2048	-	256	$368.64	$269,107.20

246

Power BI Premium with Benefits

SKU*	Capacity Units (CU)	Power BI SKU	Power BI v-cores	Hourly $	Monthly $
F2	2	-	0.25	$0.36	$262.80
F4	4	-	0.5	$0.72	$525.60
F8	8	EM/A1	1	$1.44	$1,051.20
F16	16	EM2/A2	2	$2.88	$2,102.40
F32	32	EM3/A3	4	$5.76	$4,204.80
F64	64	P1/A4	8	$11.52	$8,409.60
F128	128	P2/A5	16	$23.04	$16,819.20
F256	256	P3/A6	32	$46.08	$33,638.40
F512	512	P4/A7	64	$92.16	$67,276.80
F1024	1024	P5/A8	128	$184.32	$134,553.60
F2048	2048	-	256	$368.64	$269,107.20

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F vs RI

- F's can be paused and restarted
- RI's will be cheaper

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Administration

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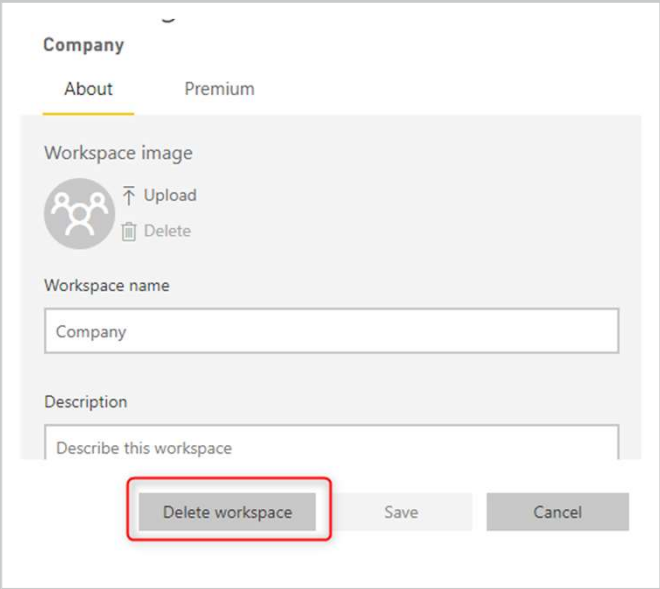
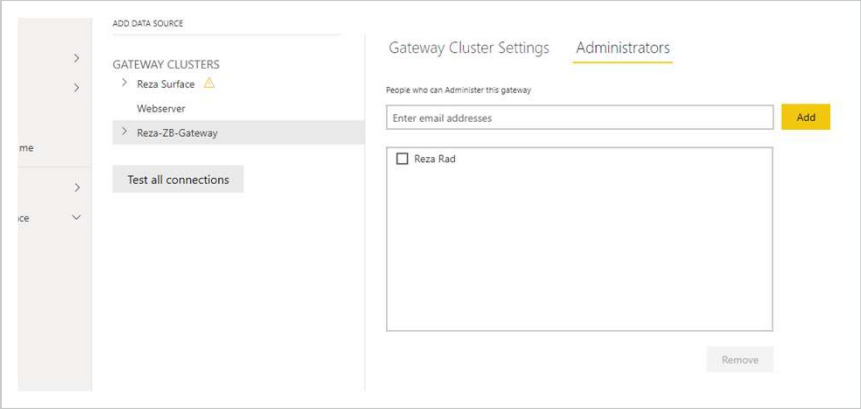
Workspace Admin

Controls the workspace and all the content in the workspace



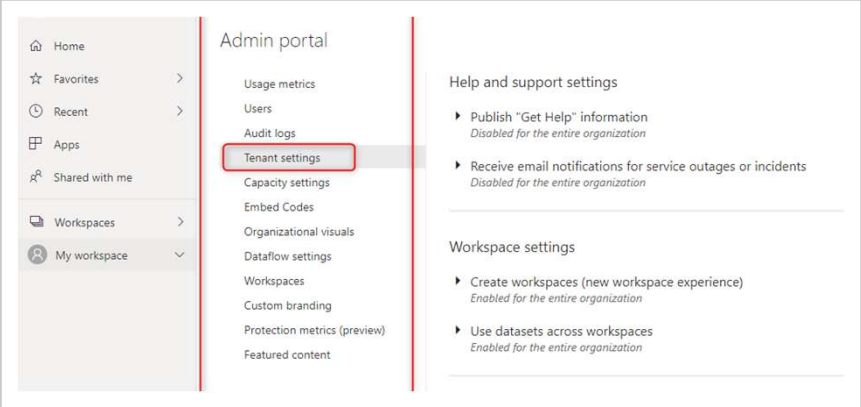
250



Gateway Admin

Controls the gateway and all the data sources under that gateway

251

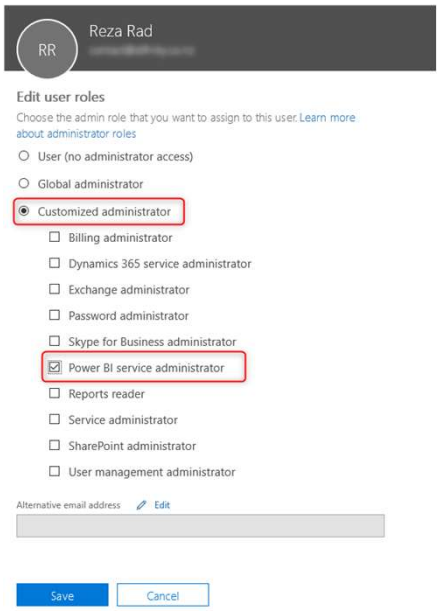


Tenant Admin

Controls the global tenant configurations

252

Power BI Service Administrator Role



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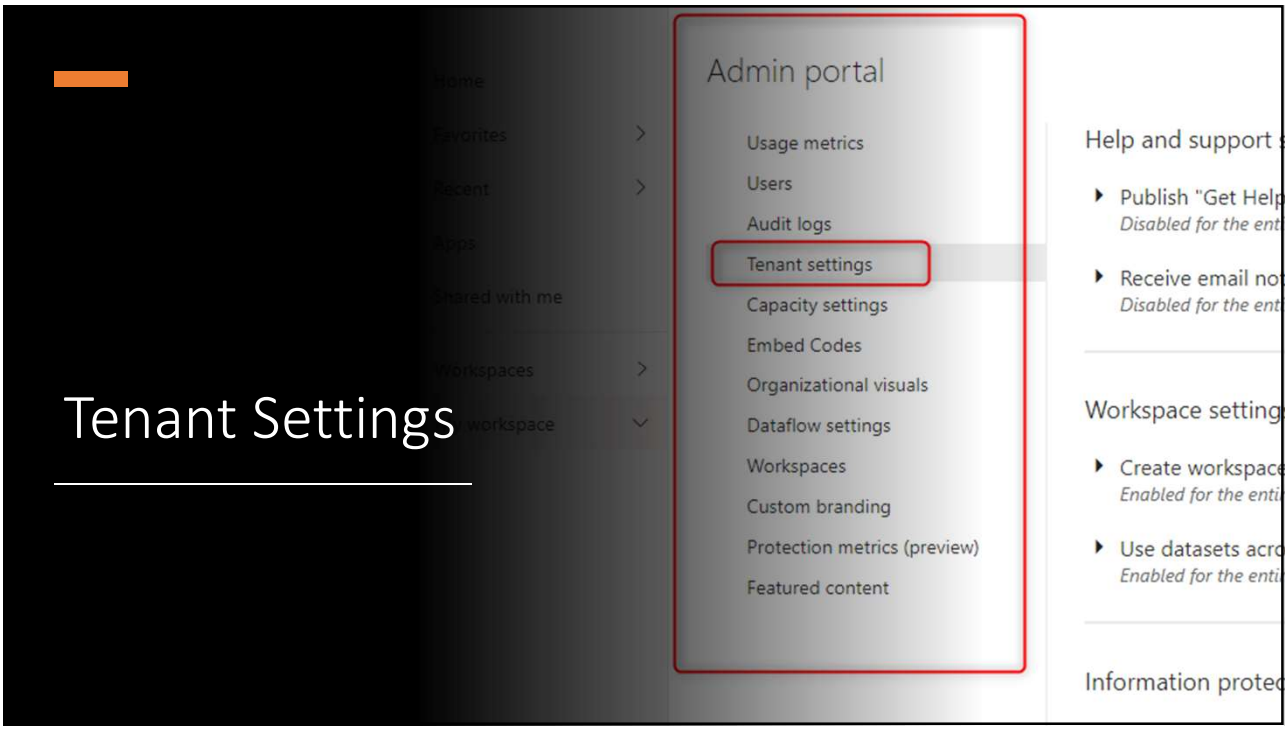
Tenant Settings



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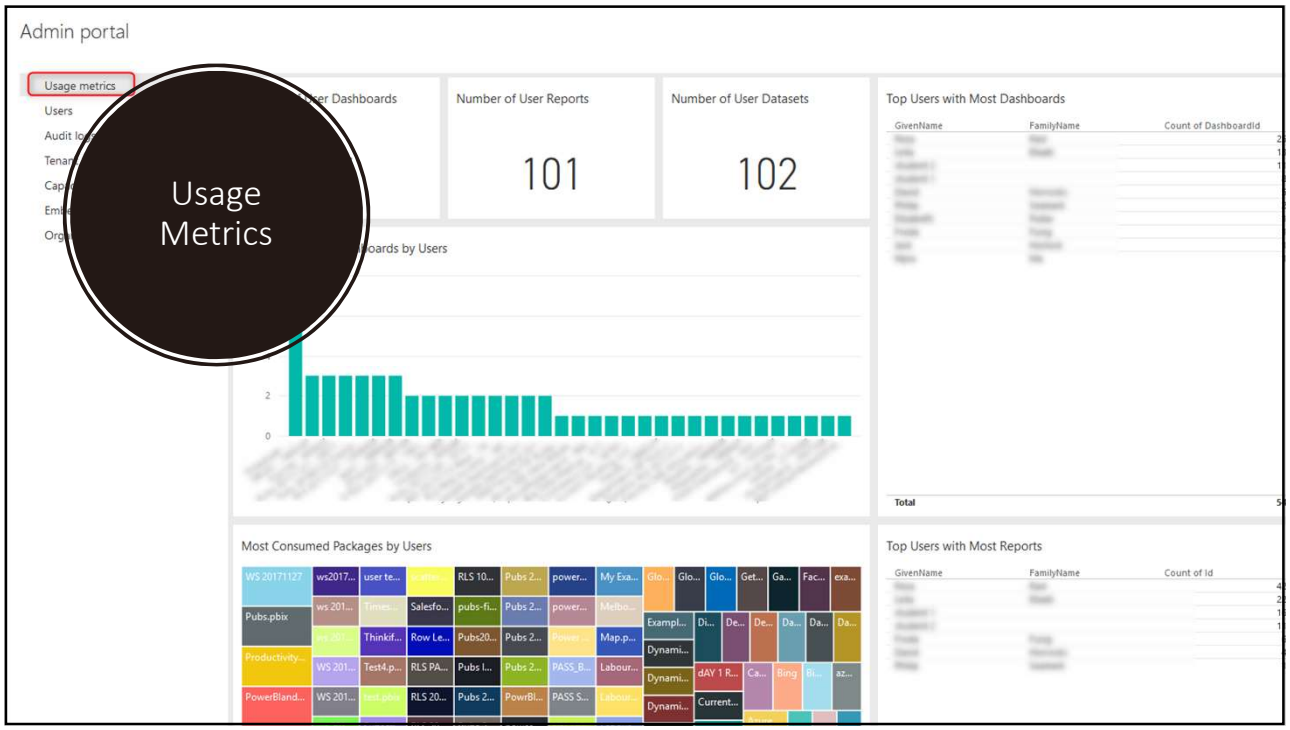

255

REST API for Power BI

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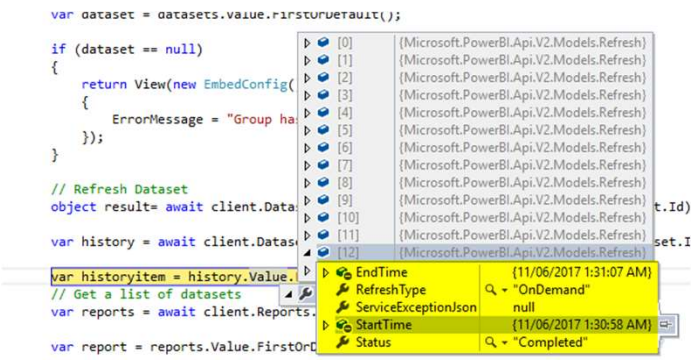
Types of usage

- .NET or Web API
- PowerShell
- Power Automate

257

Refresh Dataset



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Gateway and Data Source Management

```
var gateways = await client.Gateways.GetGatewaysAsync();

var gateway = gateways.Value.FirstOrDefault();   ≤2,696ms elapsed
var datasources = ...DatasourcesAsync(gateway.Id);
var datasource = data...
// Get a list of dash...
```

gateways	{Microsoft.PowerBI.Api.V2.Models.ODataResponseListGateway}
Odatacontext	null
Value	Count = 3
[0]	{Microsoft.PowerBI.Api.V2.Models.Gateway}
[1]	{Microsoft.PowerBI.Api.V2.Models.Gateway}
[2]	{Microsoft.PowerBI.Api.V2.Models.Gateway}
GatewayAnnotation	"{\"gatewayContactInformation\":[\"Reza@RADACAD.onmicrosoft.com\"],\"gatewayVersion\":\"14.16.6317.4\",'
GatewayStatus	null
Id	"6d418919-ba88-454e-a538-96678b6aab9b"
Name	"Reza-Vaio"
PublicKey	{Microsoft.PowerBI.Api.V2.Models.GatewayPublicKey}
Type	"Resource"

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PowerShell API

```
PS C:\Program Files\PowerShell\6> login-datagatewayserviceaccount

Environment : Public
TenantId    : cc80f8d6-3c35-4da4-b0f8-cbeadb00467e
UserName    : Reza@RADACAD.onmicrosoft.com
LoginType   : User
Password    :
Thumbprint  :
```

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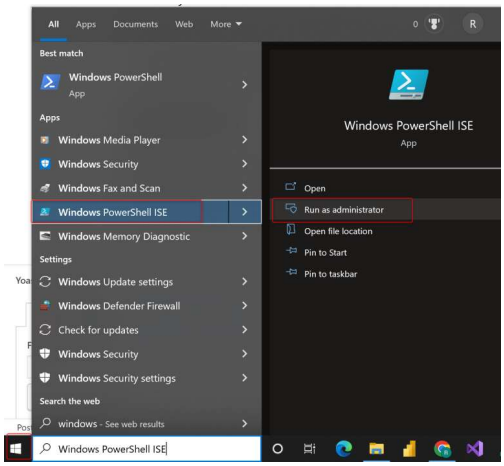
PowerShell Cmdlets for Power BI



Install-Module -Name MicrosoftPowerBIMgmt

Connect-PowerBIServiceAccount

Get-PowerBIWorkspace -All

Get-PowerBIWorkspace -Scope Organization -All

Get-PowerBIWorkspace -Scope Organization -All | ConvertTo-Csv | Out-File c:\PowerBIWorkspaces.csv

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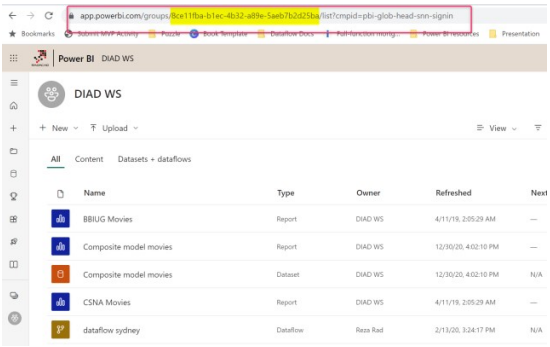
Sample Scenario: Deploy a Power BI report from one workspace to another



Get-PowerBIReport -WorkspaceId <id of your workspace>

Export-PowerBIReport -Id <report Id> -OutFile "c:\CSNA Movies.pbix"

New-PowerBIReport -Path "C:\CSNA Movies.pbix" -WorkspaceId <workspace id>

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Custom Usage Metric using Audit Log

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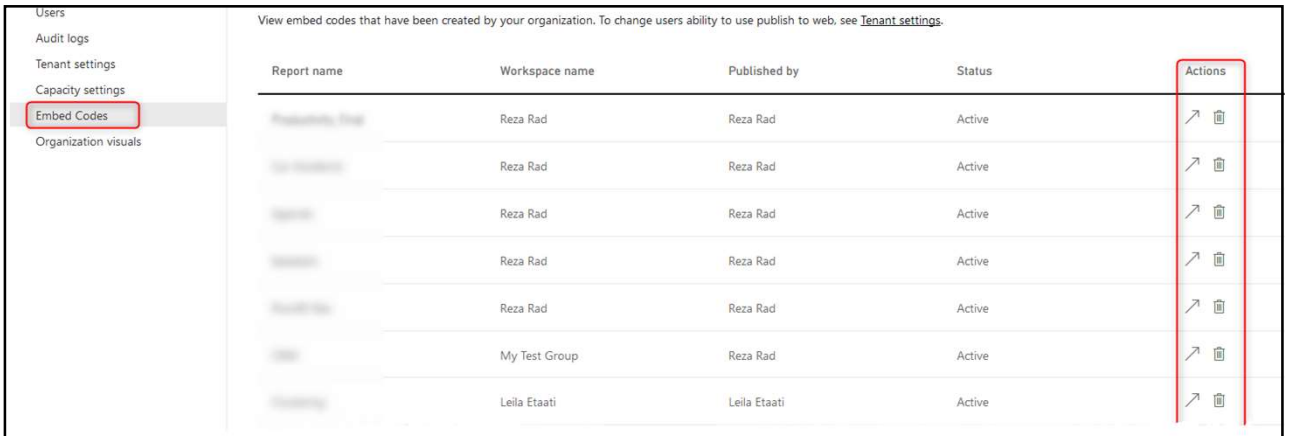

Embed Codes

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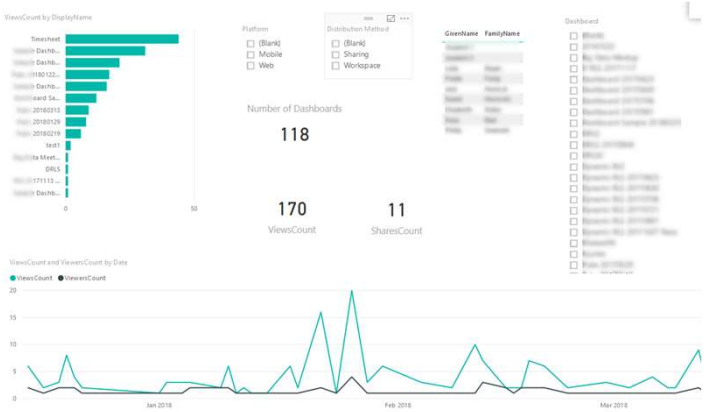
Usage Metrics



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Usage Metrics

login using admin account

---

only needed for the first time on each machine:

Install-Package ExchangeOnlineManagement

Import-Module ExchangeOnlineManagement

---

needed each time:

Connect-ExchangeOnline -UserPrincipalName reza@radacad.com

get the audit log

---

only needed for the first time on each machine:

Install-Package ExchangePowerShell

Import-Module ExchangePowerShell

---

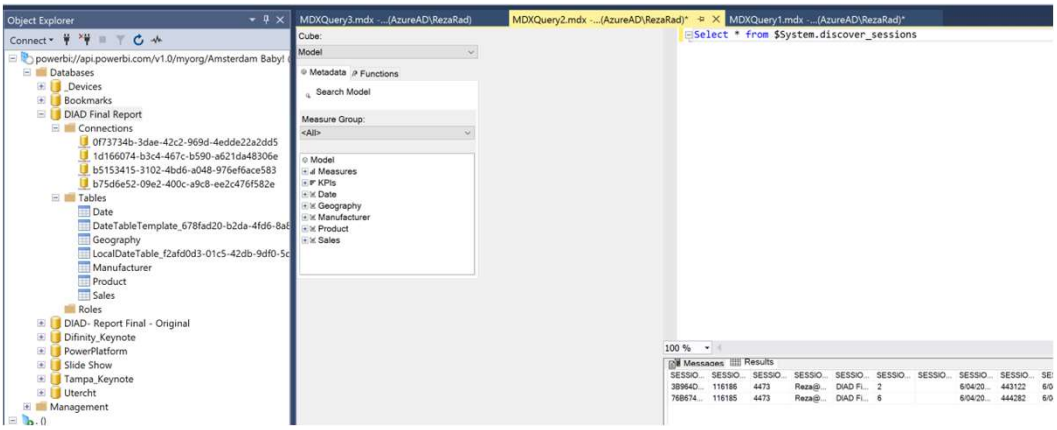
needed each time:

Search-UnifiedAuditLog -StartDate (Get-Date).AddDays(-90) -EndDate (Get-Date) -RecordType PowerBIAudit -ResultSize 10

Search-UnifiedAuditLog -StartDate (Get-Date).AddDays(-90) -EndDate (Get-Date) -RecordType PowerBIAudit -ResultSize 5000 | ConvertTo-Csv | Out-File c:\PowerBIAuditLog.csv

266

XMLA Endpoint



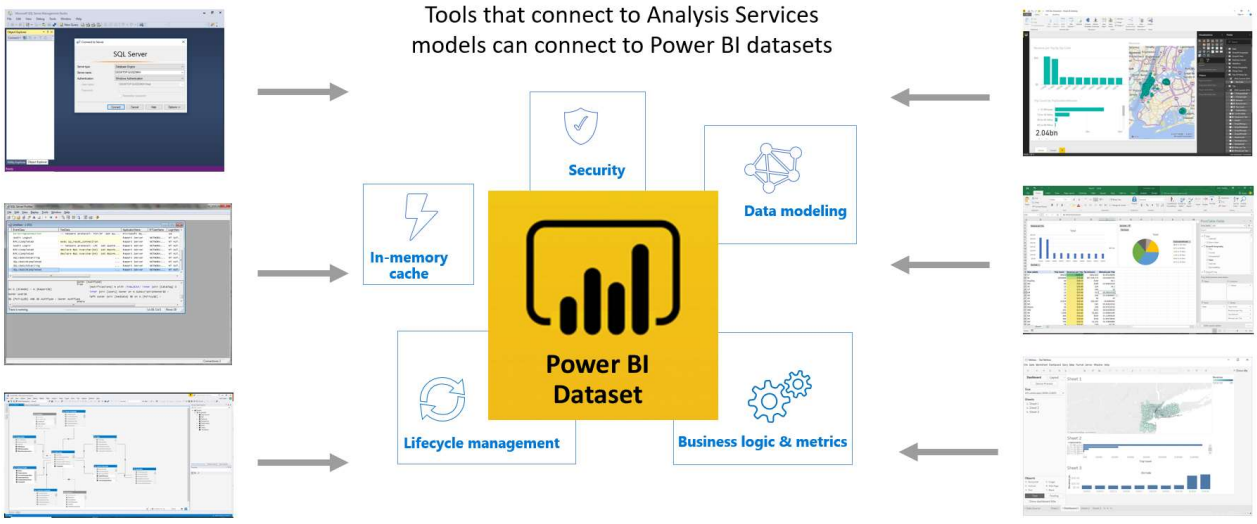
267

Centralized reporting and analytics

Modeling, management and debugging tools

Tools that connect to Analysis Services models can connect to Power BI datasets

Data visualization tools including non-Microsoft



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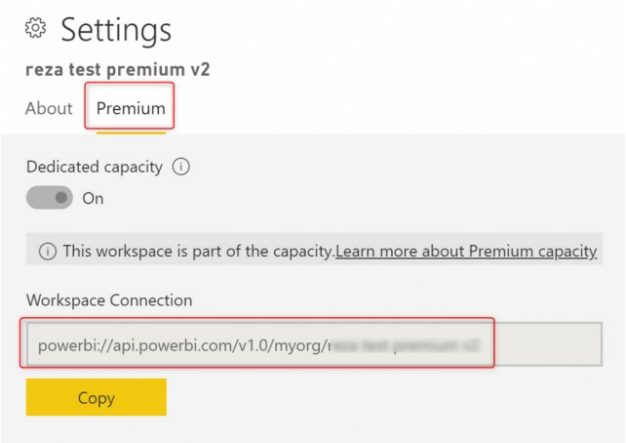
Premium Only



269

Content certification and governance

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Certification

Bronze → Silver → Gold

No certification → Promoted → Certified

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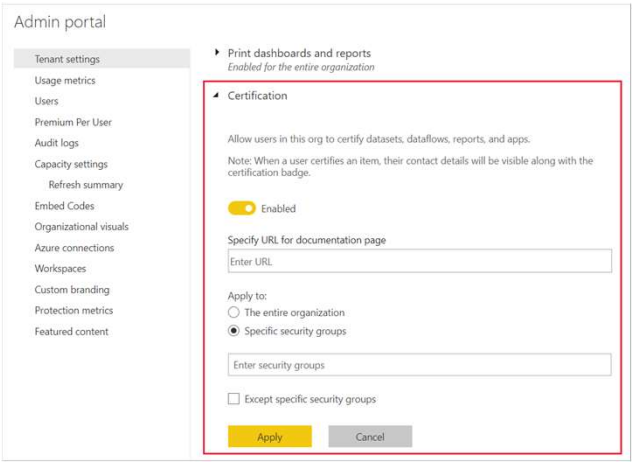
Setup for Certification



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What can be certified?

- Dataflow
- Dataset
- Report
- App

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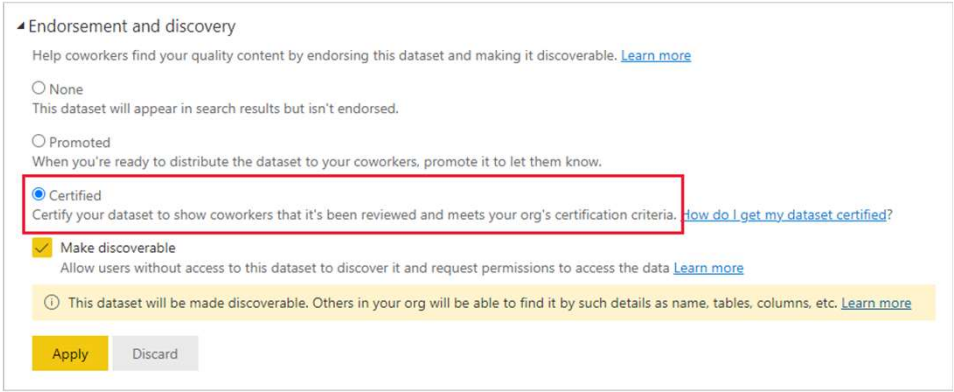
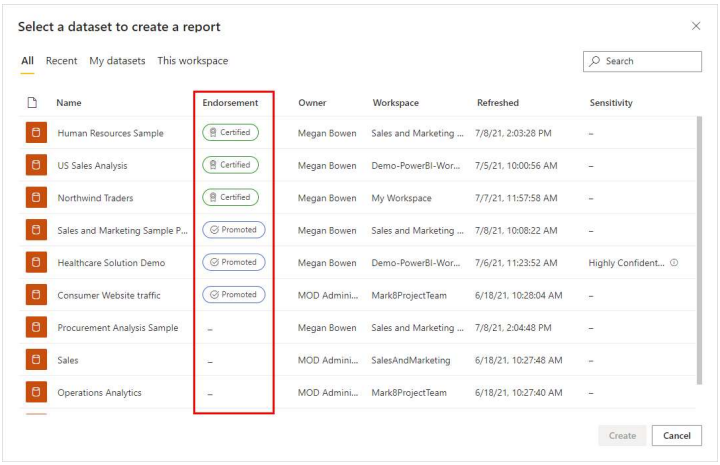
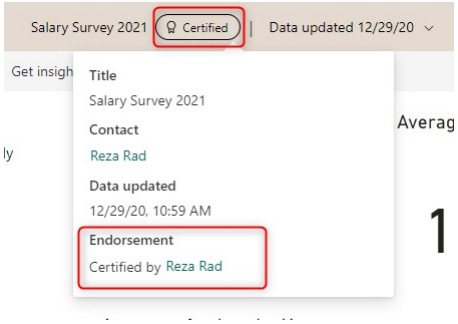
Certifying content



274

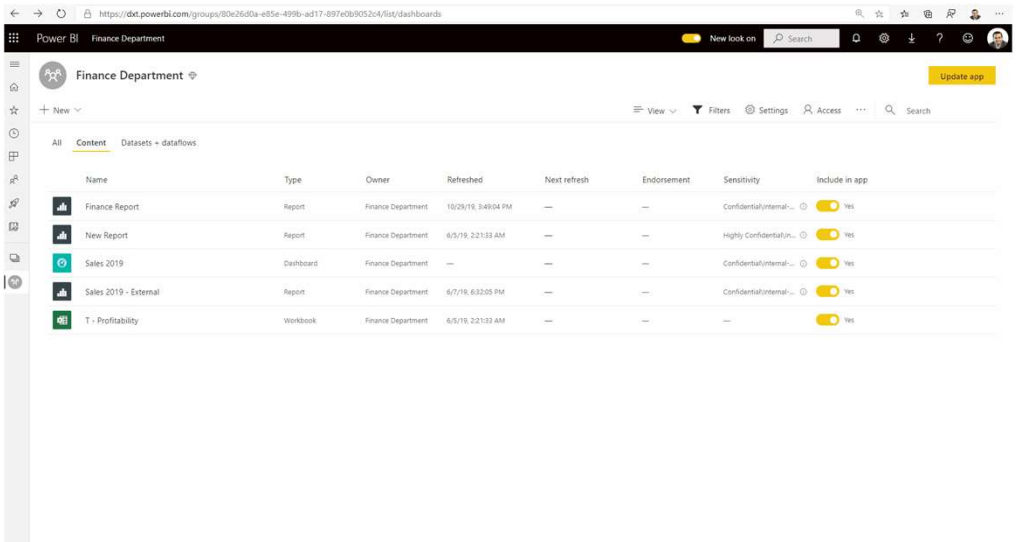
Certified content





275

Sensitivity Label



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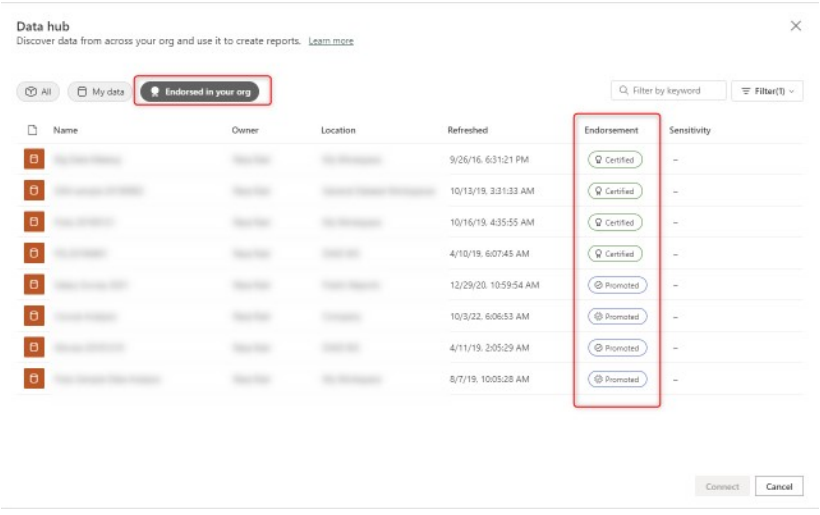
The PROCESS is important, not the feature

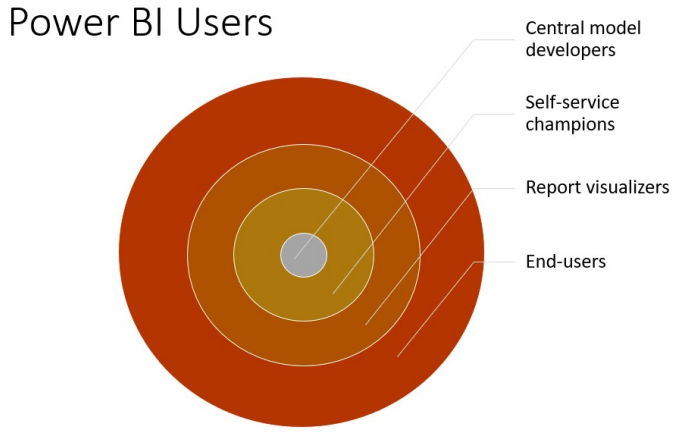


277

The importance of knowing different types of Power BI users; a governance approach

278

There are different types of Power BI users.



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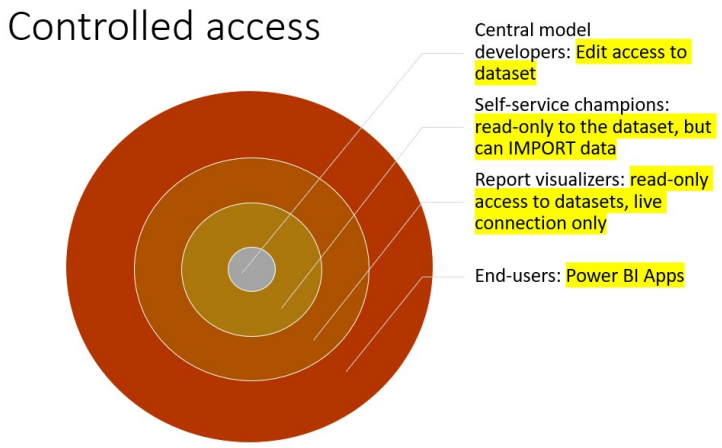
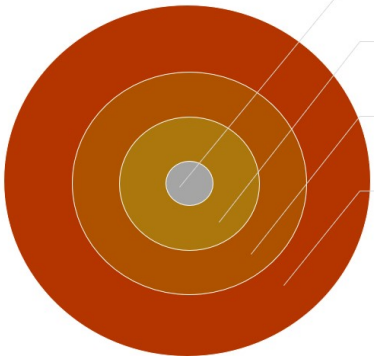
Access Control



280

Training

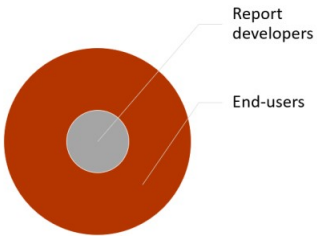
Training



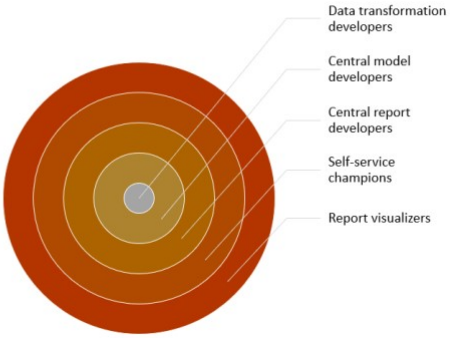
281

The layers and user categories are different in each organization

Small businesses



Layers within layers



282

Why knowing Power BI users is essential?

- Spending too much training budget when not needed
- Losing interest in downstream user layers
- Upstream user layers will likely start their own way of doing things
- The mix-up will hurt the governance more than anything else
- The trust in Power BI in the organization will vanish slowly
- Power BI adoption may fail

Users can move between layers

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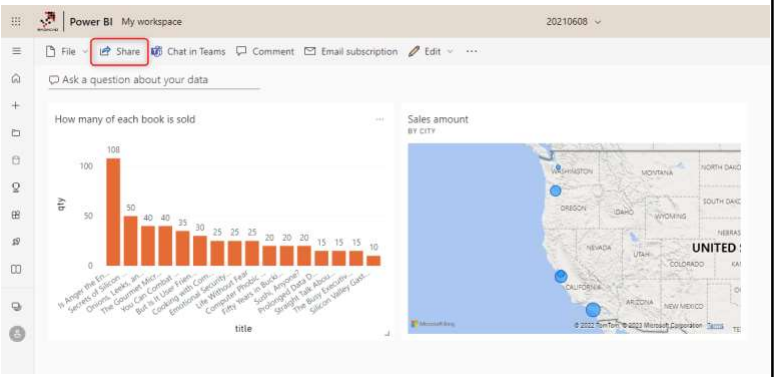
Sharing Methods

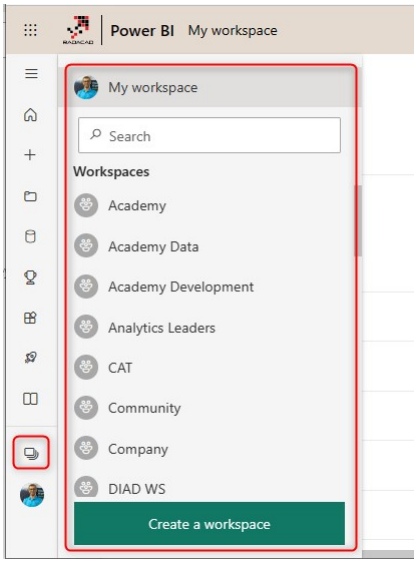
284

Basic Sharing



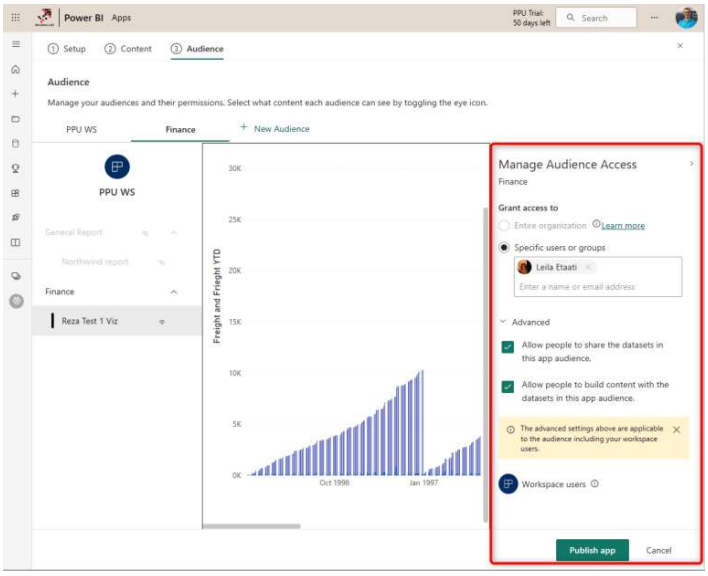
285

Workspaces



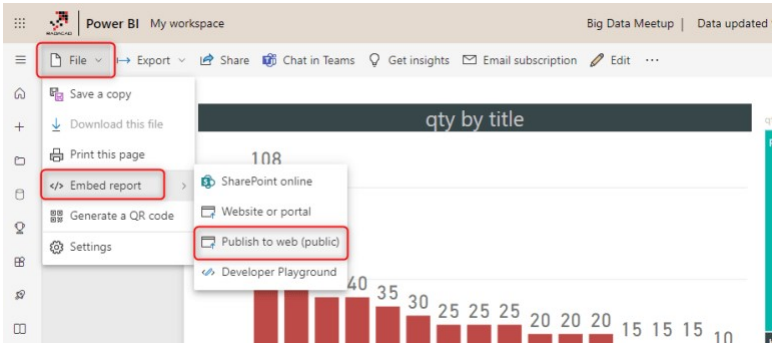
286

Power BI App



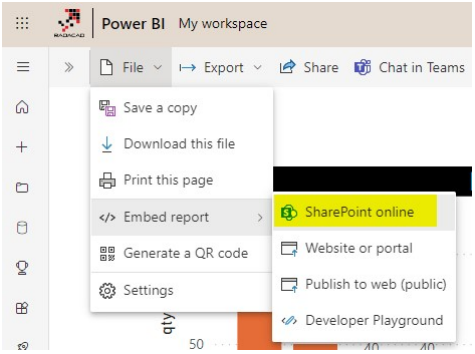
287

Publish to Web



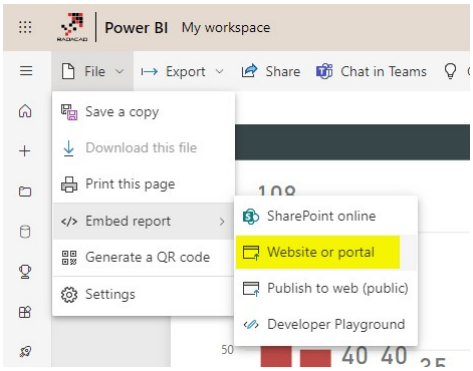
288

Embed in SharePoint Online



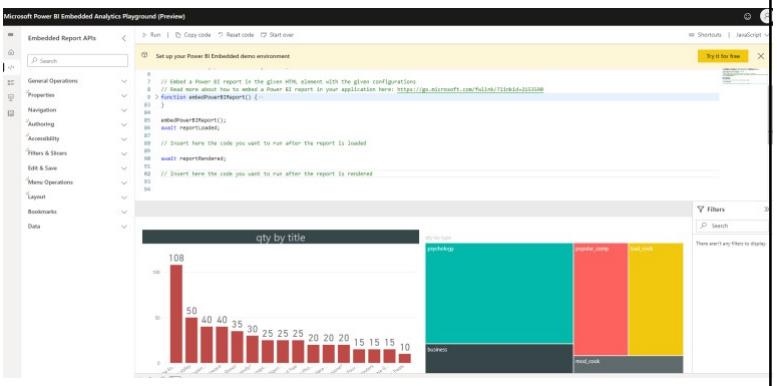
289

Secure Embed



290

Power BI Embedded



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Comparison: Methods of Sharing

	Basic Sharing	Workspace	Power BI App	Publish to web	SharePoint Online	Power BI Embedded	Secure Embed
FREE				Yes			
No Power BI account needed				Yes		Yes	
Access Levels Secure	Read Yes	Read/Edit Yes	Read Yes	Read	Read Yes	Read/Edit Yes	Read Yes
Dev/User Environment			Yes				
Sharing Multiple Items		Yes	Yes				
Extras						the need for Web Developer	

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Cheat sheet of Which Method to Choose

Basic Sharing	A fast and quick method of sharing for testing reports and dashboards
Work Space	great option for collaborative development environments between Power BI Developer teams
Power BI App	best option to share reports with end users in a user environment which is isolated from the developer environment
Publish to the web	The free method of sharing, best for public data sets where the nature of data is not confidential
SharePoint Online	good choice when SharePoint online is the current portal for users in the organization
Power BI Embedded	an option to bring Power BI content into your application, when the user management can be done in the application specifically
Secure Embed	Sharing simply and securely in SharePoint on-premises or a custom web application without the need for a web developer

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Workspace Structure

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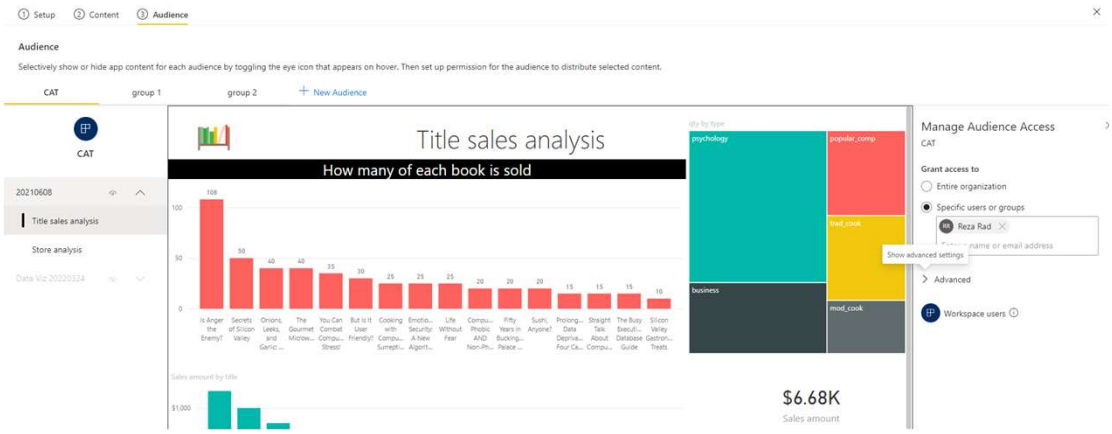
Separating audiences with multiple workspaces

Separate workspaces for different audiences

295

[New]: One workspace, one app, multiple audiences



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Shared workspaces

Shared workspaces: Less redundancy

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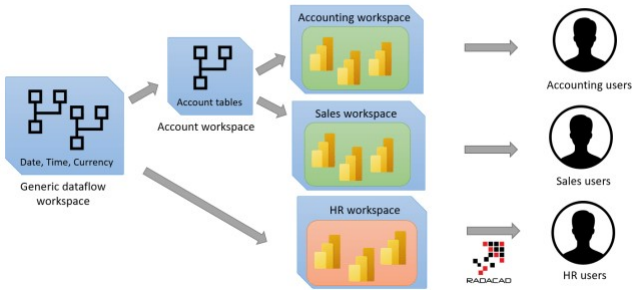
Layered workspace structure

Shared workspaces: Layers



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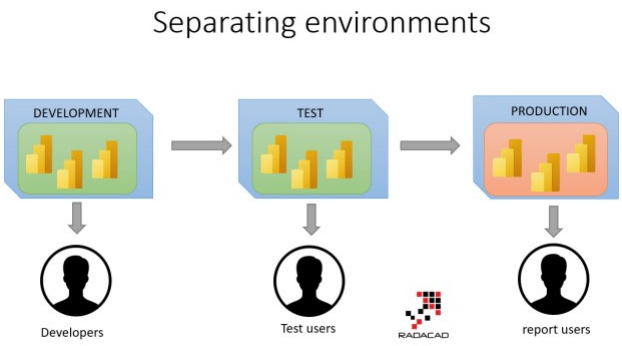
Separating environments



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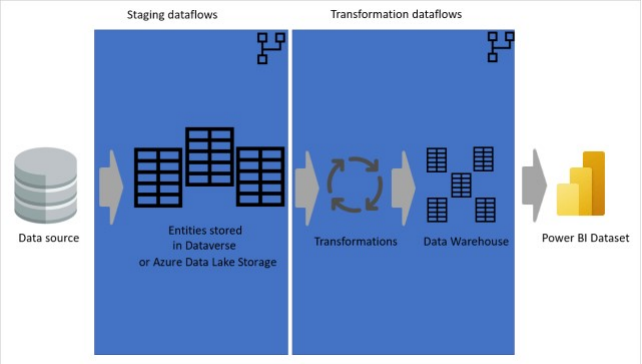
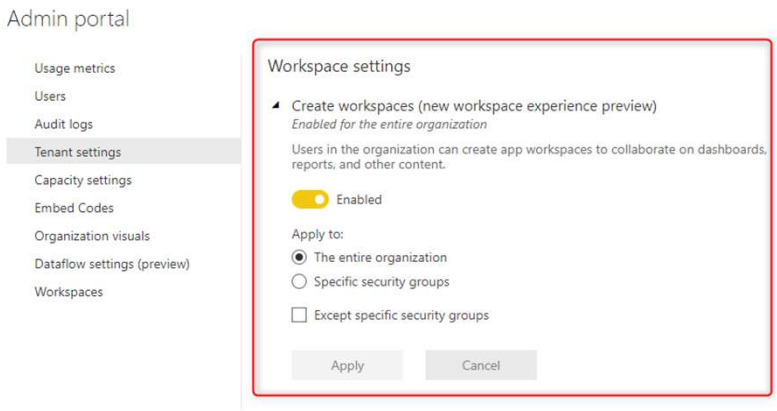
Workspaces as development layers

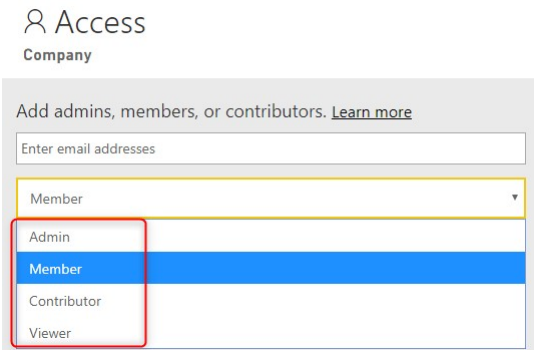


300

Admin Portal Configuration for Workspace



301



Workspace Roles

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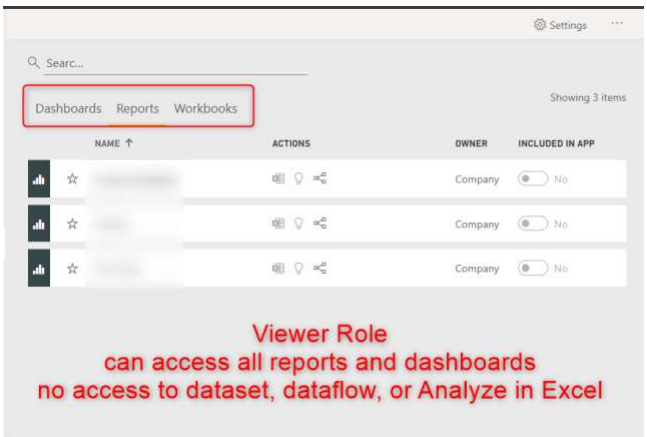
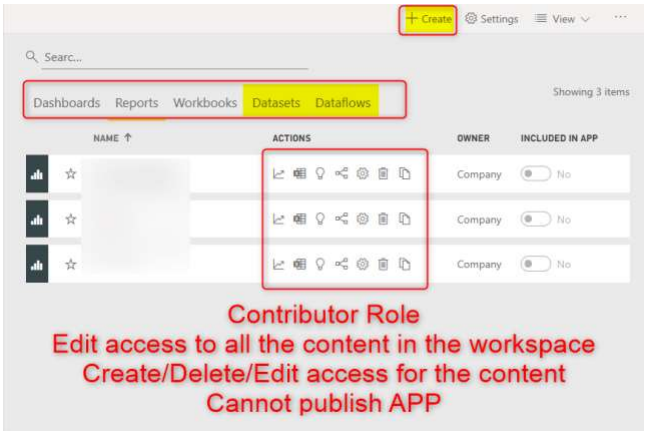
Viewer



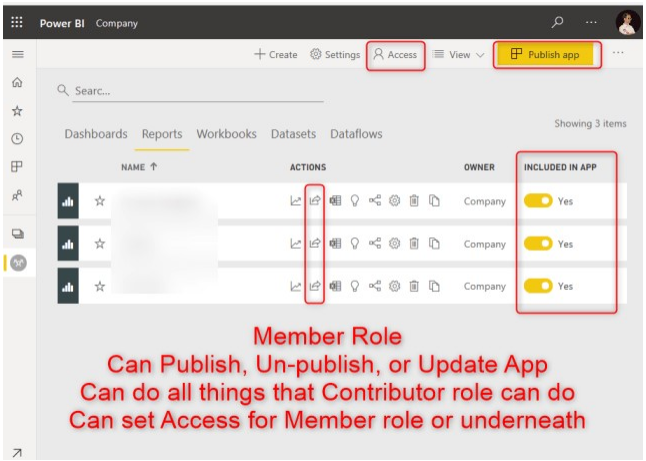
303

Contributor



304

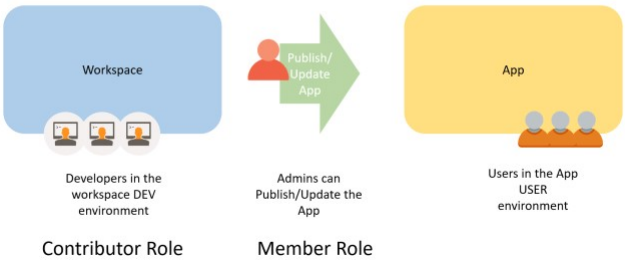
Member



305

Member Vs. Contributor

New Version of Workspace (V2): Developers CANNOT Publish/Update app mistakenly. Member Role can do that.



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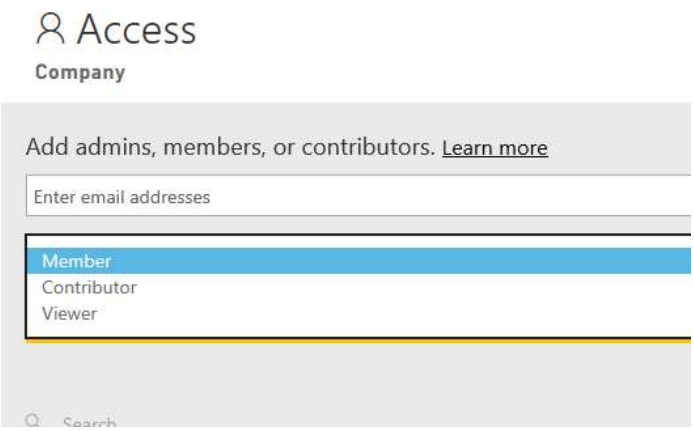
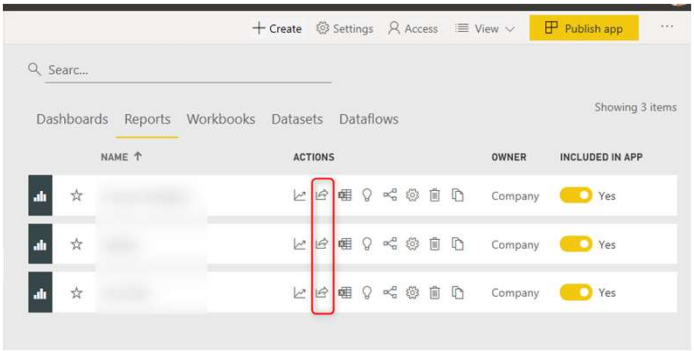
Member can set up the access



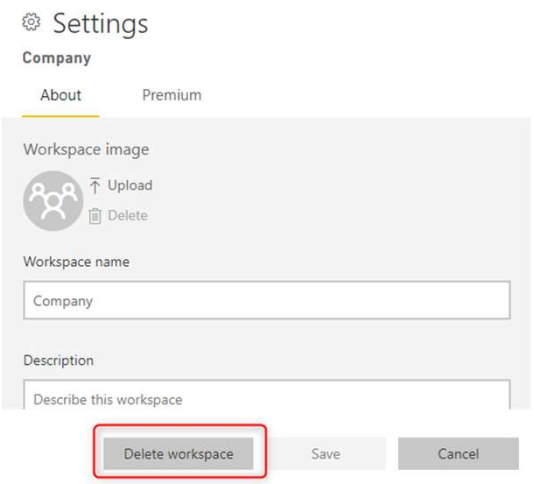
307

Member Can Share



308

Admin



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Summary

Role	Usage
Viewer	Don't use. Use Power BI App instead
Contributor	Developer Group only
Member	Deployment Group
Admin	The workspace admin

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Deployment Pipelines

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Benefit of multiple environments

- Users not getting affected by the changes made by developers
- A defined process to push changes and updates
- An environment for test without affecting the load on live users
- …

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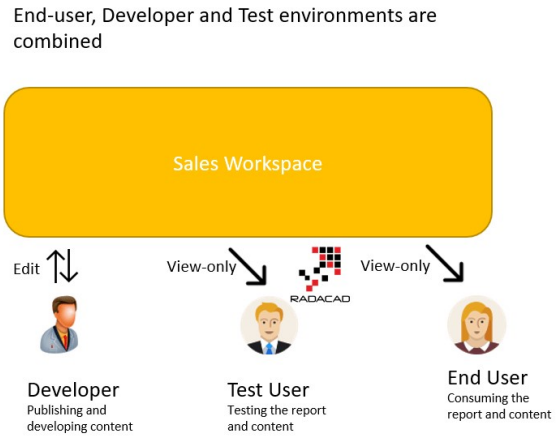
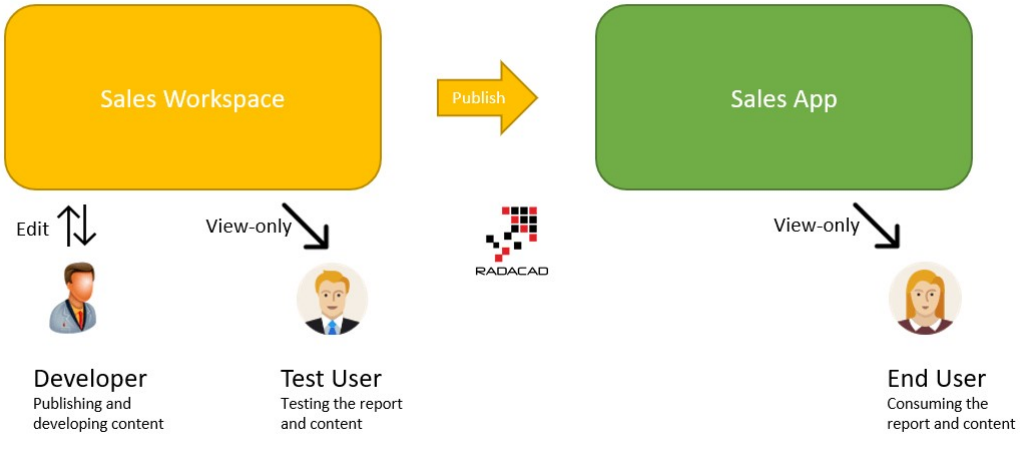
Sample Power BI Implementation with all the environments combined



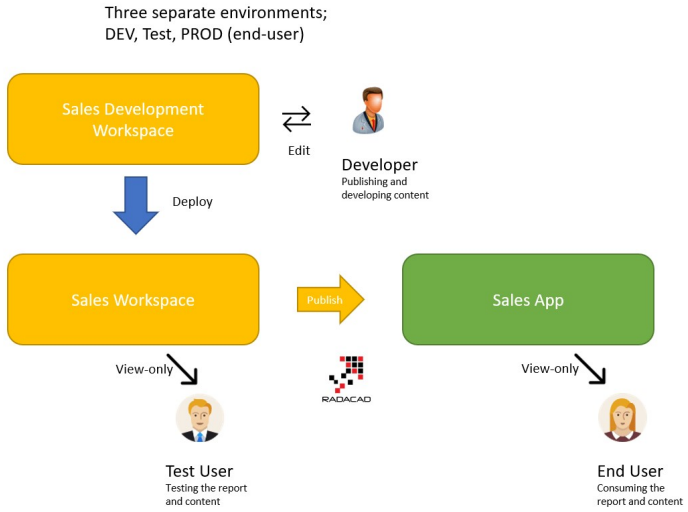
313

Sample Power BI implementation with the end-user environment separated



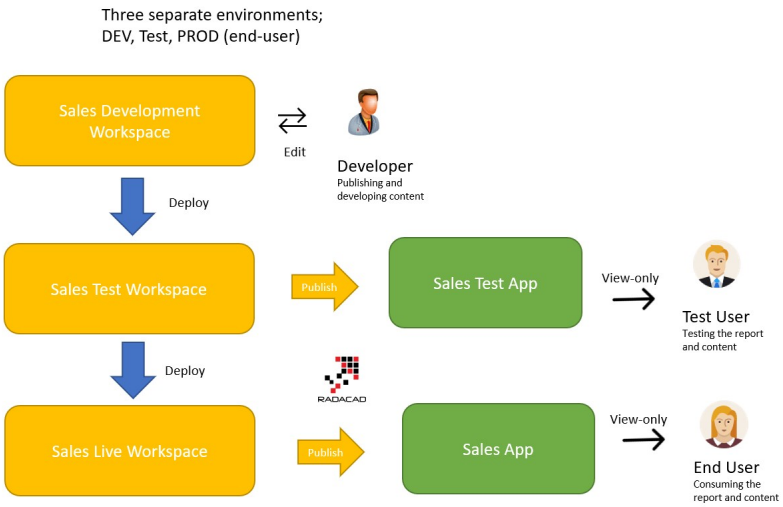
314

Separating the Power BI developer and test user's environment



315

Three separate environments in Power BI with separate workspaces and apps



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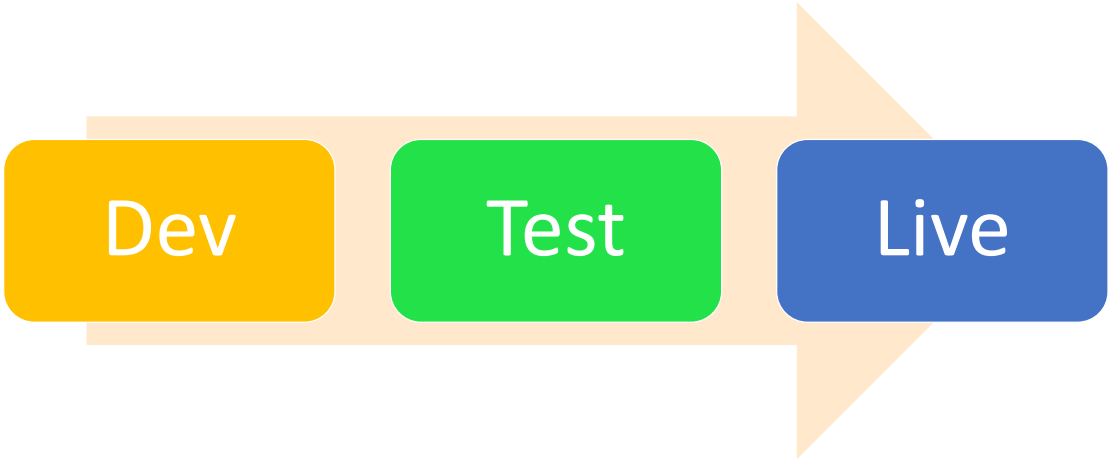
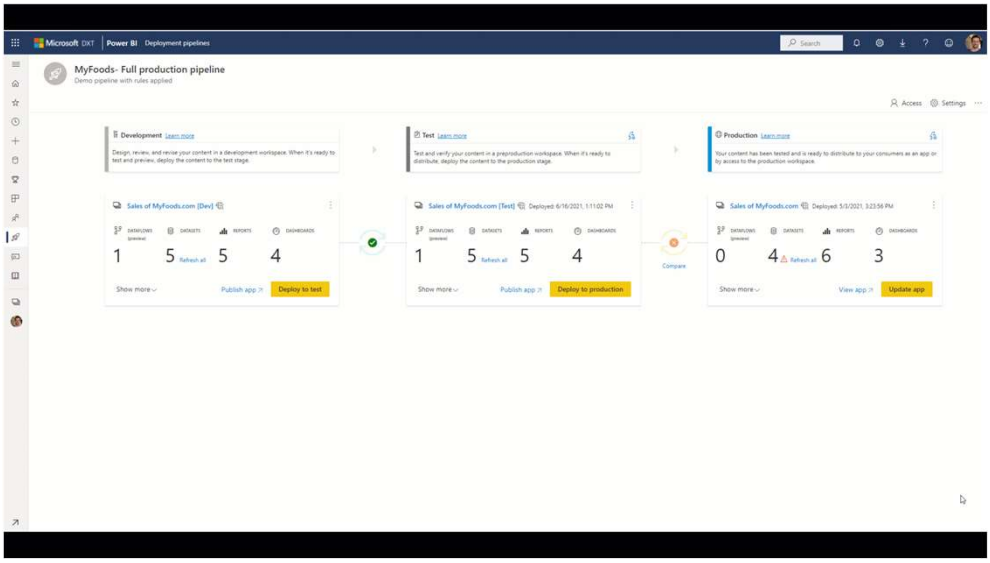
Common environments



317

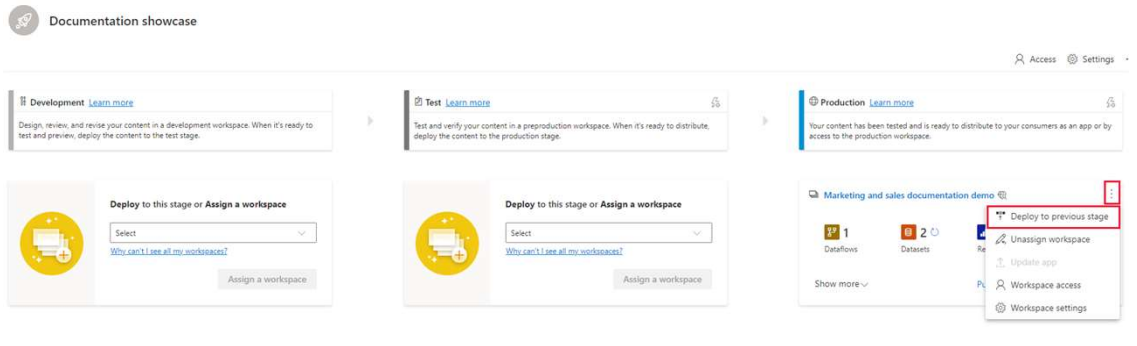
Push changes to the next environment



318

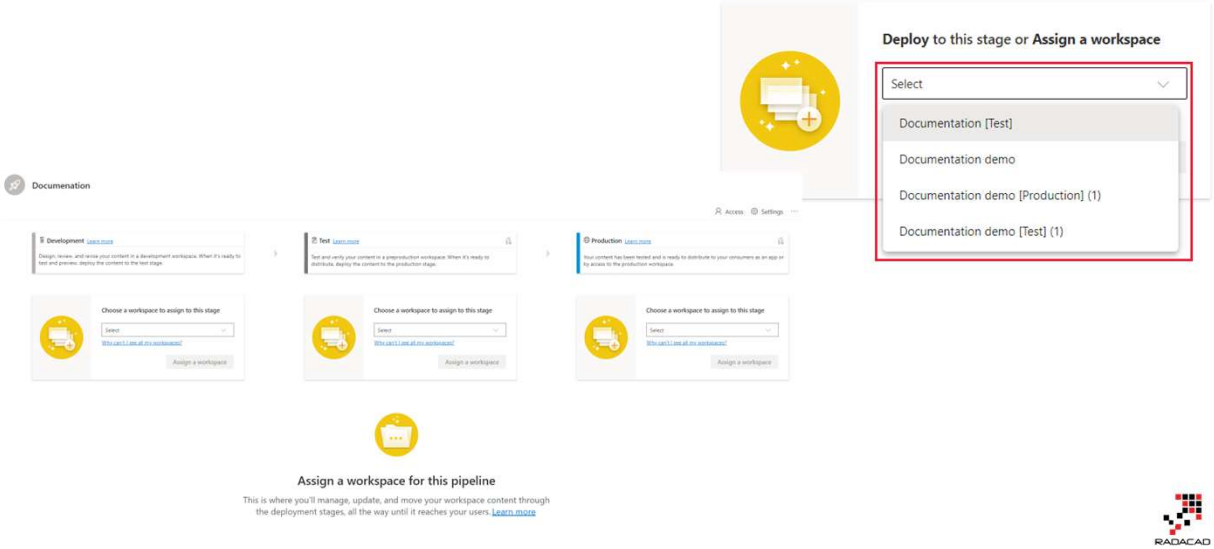
Deployment options

- Deploy all
- Selective Deploy
- Backwards deployment (previous stage)



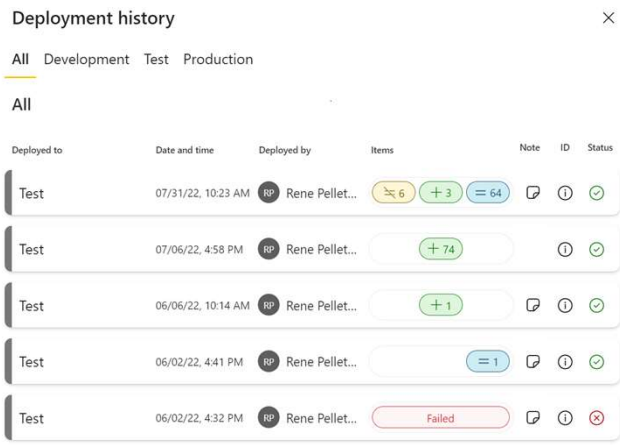
319

Assign workspaces to pipeline stages



320

Deployment history



321

Deployment Best Practices

- Define the workspace structure early
- Setup workspace roles and access levels with caution
- Always use Active Directory groups instead of individual emails
- Have multiple environments (Dev, Test and Prod)
- Automate the deployment pipelines

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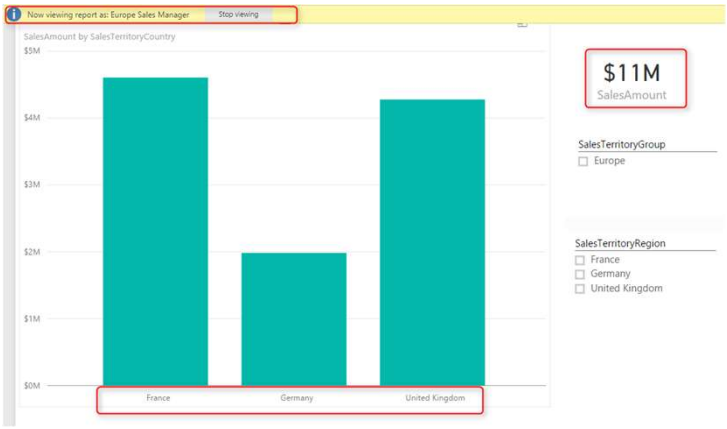
Row Level Security



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Static Row Level Security

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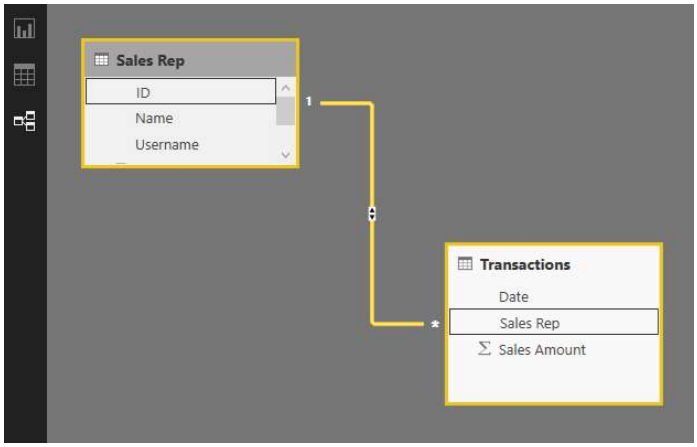
Dynamic Row Level Security



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A few Dynamic RLS Patterns

- Manager Level Access
- Users and Profiles
- Organizational Hierarchy

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Manager Level Access

Name	Sales Amount	Year	Quarter	Month	Day
Leila Etaati	300	2017	Qtr 1	February	1
Reza Rad	100	2017	Qtr 1	January	1
Reza Rad	50	2017	Qtr 1	March	1
Total	**450**				

Manager View

Manager will see all records from all users

student2@radacad.com

Measure

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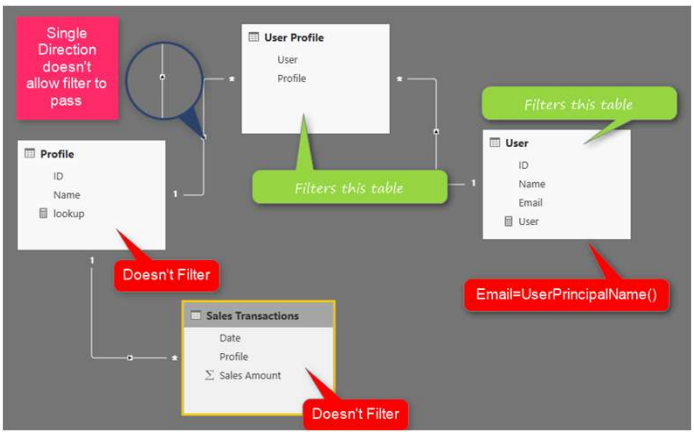
Users and Profiles



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Organizational Hierarchy

Every Employee should see his/her own records + records of people under him/her

Name	Year	Quarter	Month	Day	Sales Amount
Amy	2017	Qtr 1	January	1	100
Bill	2017	Qtr 1	February	1	300
David	2017	Qtr 2	April	3	340
Justin	2017	Qtr 1	March	1	50
Leila Etaati	2017	Qtr 2	April	4	35
Lindsay	2017	Qtr 2	April	1	150
Mark	2017	Qtr 2	April	2	30
Mark	2017	Qtr 2	April	10	40
Reza Rad	2017	Qtr 2	April	5	20
Total					**1065**

Organization Chart
- Leila Etaati
  - Justin
  - Mark
    - Bill
- Reza Rad
  - Amy
    - Lindsay
  - David

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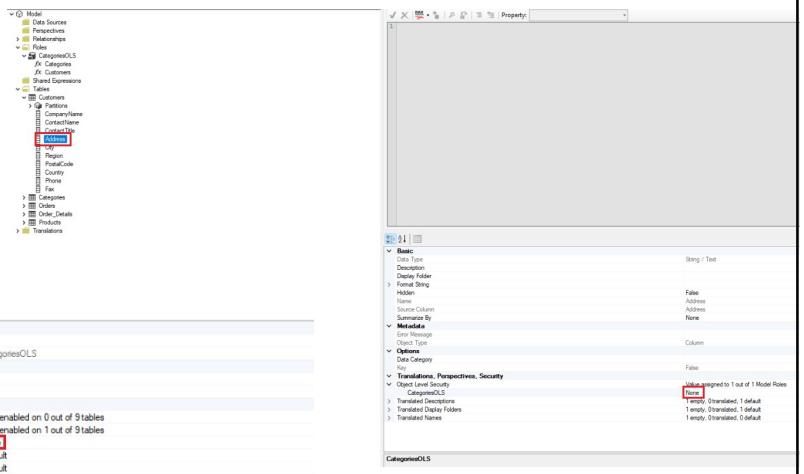
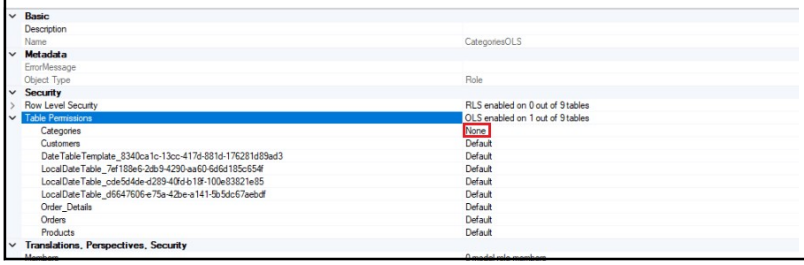
OLS and CLS

- Object Level Security
- Column Level Security





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Git | Source Control

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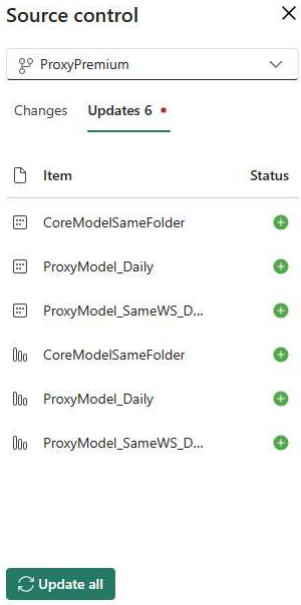
Why GIT Integration?

- Back up and versioning
- Revert to previous stages if needed
- Collaboration using Git branches
- Source control



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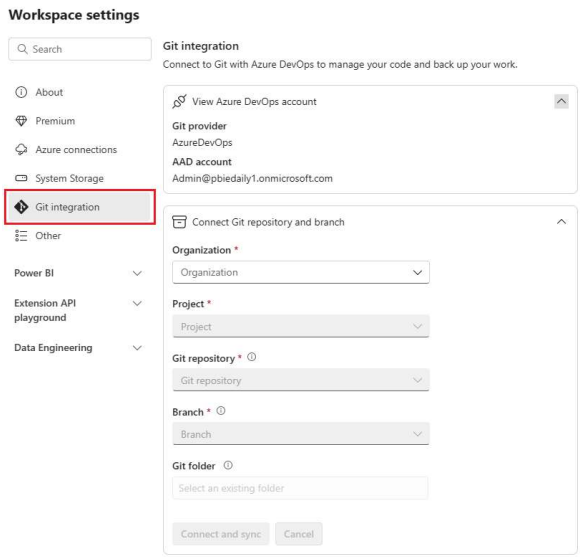
Considerations and Limitations

- Not all items supported (for now)
- Only Git in Azure Repos

334

Workspace settings for Git integration



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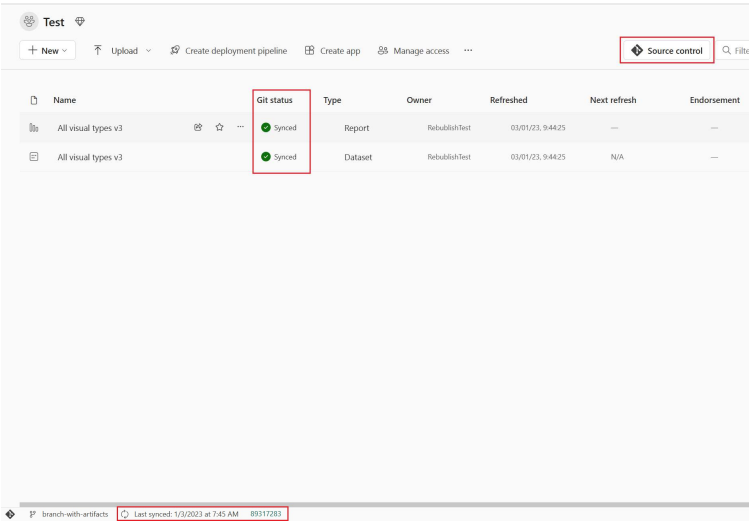
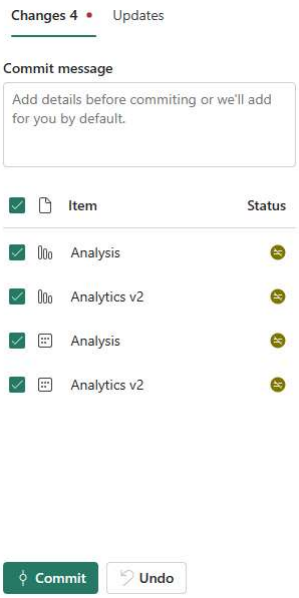
Sync and Commit changes





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Fabric

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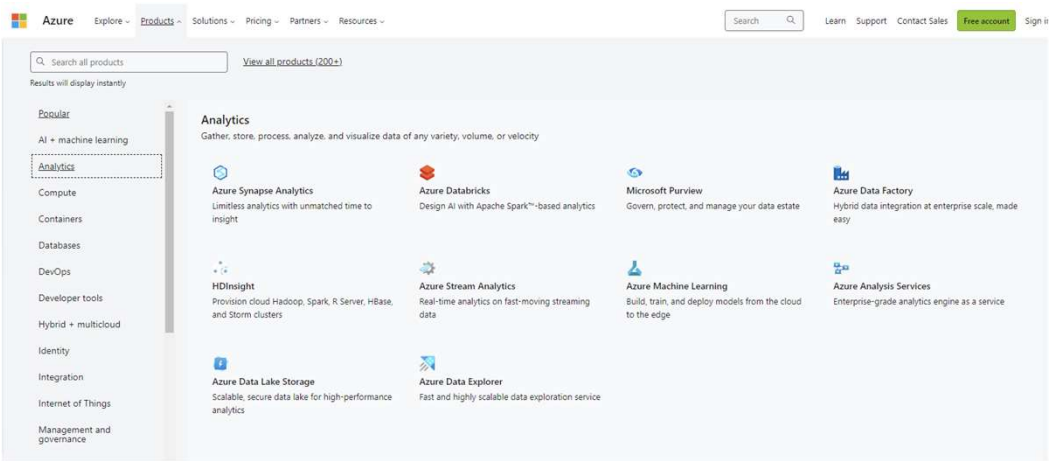
Complexity Level: HIGH



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Microsoft Fabric: For Simplicity

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Microsoft Fabric: An Umbrella

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What's in the box

- Storage; OneLake
- Data Integration; Data Factory
- Data Engineering; Synapse
- Data Warehousing; Synapse
- Data Science; Synapse
- Real-Time Analytics; Synapse
- Business Intelligence; Power BI
- Action platform; Data Activator
- Governance; Purview

341

A tool that helps (FREE)

Power BI Helper

https://powerbihelper.org

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Review Development

- Import Data or Schedule Refresh
- DirectQuery
- Live Connection
- Composite Mode
- DirectQuery to Power BI Dataset
- Choosing the Right Connection Type
- Dataflows
- Shared Datasets
- Datamart
- Multi-Developer Architecture
- Dataflow vs Dataset vs Datamart
- Paginated Reports
- Analyze in Excel
- Realtime streaming with Power BI
- Power BI Aggregations
- Incremental Refresh
- Power BI Development Best Practices

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Review Deployment

- Power BI Service
- Power BI report server
- Gateway and configurations
- Licensing guide (and PPU)
- Premium settings and configurations
- Tenant settings
- Admin reports and metrics
- Workspace structure and architecture
- Workspace roles
- Deployment pipelines
- REST API for deployment and administrations
- XMLA endpoint

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Review Sharing

- Content certification and governance
- Individual sharing
- Workspace sharing
- App
- Embed code and publish to web and embed in sharepoint
- Teams integration and Sharepoint online
- Power BI Embedded
- Compare sharing methods
- Usage metrics
- Usage metrics API and PBI Helper
- RLS and Dynamic RLS
- OLS

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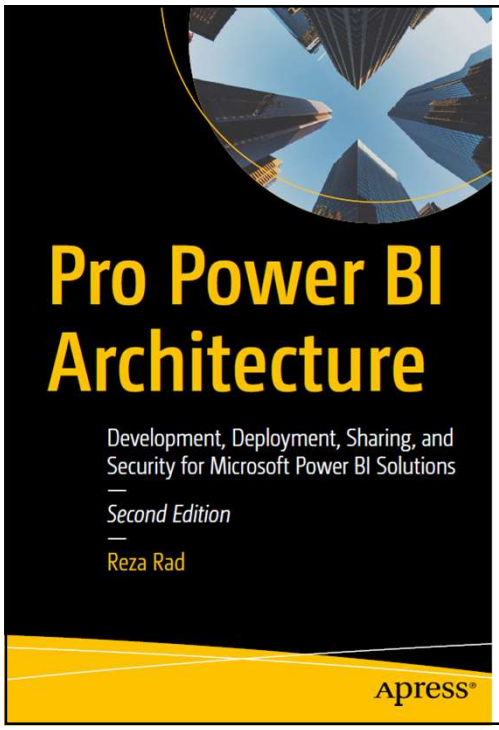

Pro Power BI Architecture Book

- https://www.amazon.com/Pro-Power-Architecture-Development-Deployment/dp/1484295374

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